Medical Filmless Imaging System
6525-01-480-2199

CONSISTING OF:

MODEL	DESCRIPTION
CR2000ML	CR2000ML COMPUTED RADIOLOGY SYSTEM
	INCLUDES: PANSONIC PENTIUM III 900
	LAPTOP 13.3” TOUCH DISPLAY
	WINDOWS 2000
	INTERNAL CDRW, 256MEG RAM
	SCSI CARD, DI3000 ACQUISTION SOFTWARE
	POWER PACS CD SOFTWARE
	CR ACCESSORIES
C2400	CR CASSETTES 24X30CM(10”X12”)
C3500	CR CASSETTES 35X43CM(14”X17”)
GA70-837	PHOSPHOR CR PLATES 24X30CM(10”X12”)
GA70-838	PHOSPHOR CR PLATES 35X43CM(14”X17”)
GC101	24X30 GRID CAP WITH 6:1 RATIO, 103LPI
GC102	35X43 GRID CAP WITH 6:1 RATIO,103LPI
TL2000	TOUGH LITE ERASER
HF100H	HIGH FREQUENCY PORTABLE X-RAY UNIT WITH PORTABLE STAND
SR801RT	MULTI-PURPOSE TABLE WITH BRAKES
SR800RS	RAVEN STRETCHER
GA500	UNITERRUPTIBLE POWER SUPPLY APC500
GA015	EXTENSION CORD 15’
GA 100	COMPACT STOOLS
CH661	TRANSPORT CONTAINER FOR CR2000-ML & HF-100H X-RAY UNIT
CH661T	EQUIPMENT MOUNTING ASSEMBLY(TABLE TOP)
CH101M4	4 WHEEL CART WITH BRAKES
CH2000	PACKAGING INSERTS FOR CR2000-ML CONTAINER
CH2001	PACKAGING INSERTS FOR HF-100H CONTAINER
	RADIATION AND FLUID PROTECTION KIT
MT500	LEAD APRON
MT502	LEAD HALF APRONS
MT503	LEAD GLOVES
MT504	LEADED THYROID SHIELD
MT505	LEAD MARKER SET
MT506	11”X14” LEAD BLOCKER
	CONSUMABLES
CD200	100 BLANK CD-R’S
A66-17-53	200 VINYL EXAMINATION GLOVES
A270-54H	100 18X20 2MIL ZIPPER BAG
A277-4-05W	100 6”X6” 2MIL ZIPPER BAG
SP877-1	100 SAFETY PINS
A500-300	6 PERMANENT MARKERS
DW301	120 DISINFECTING WIPES
EW401	100 ACOHOL WIPES
QA101	MAINTENANCE KIT

Setup for the Medical Filmless Imaging System

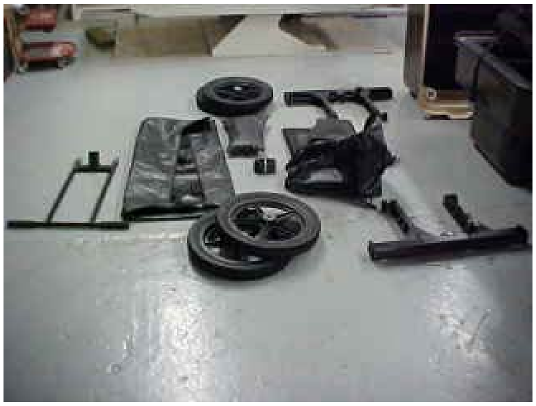
CONTAINER'S A & B

CONTAINER A & B WITH TOP REMOVED.

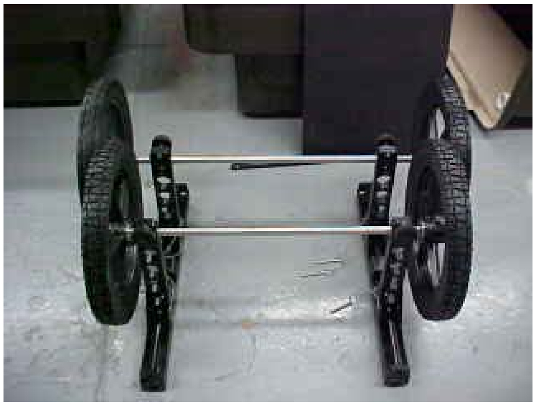
CONTAINER A WITH THE SR801RT
CART BAG UNZIPPED

CH101M4 4WHEEL CART WITH BRAKES

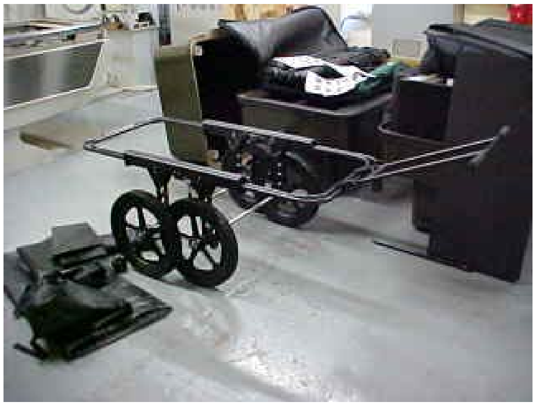
CH101M4 CART WITH WHEEL'S



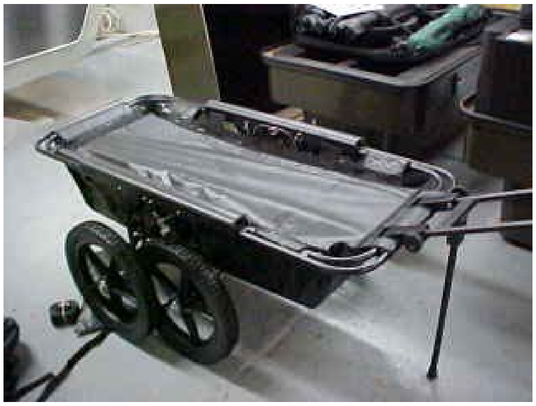
CH101M4 4WHEEL CART WITH BRAKES
PLACED ON THE FLOOR

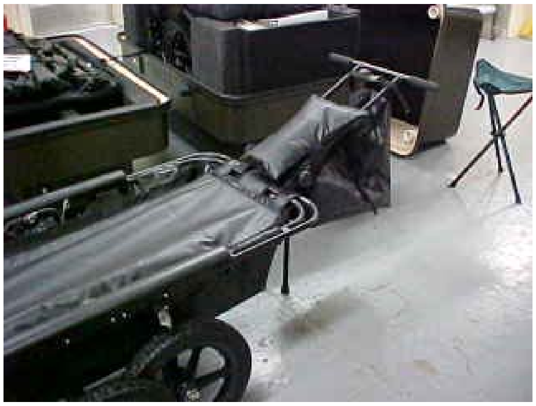


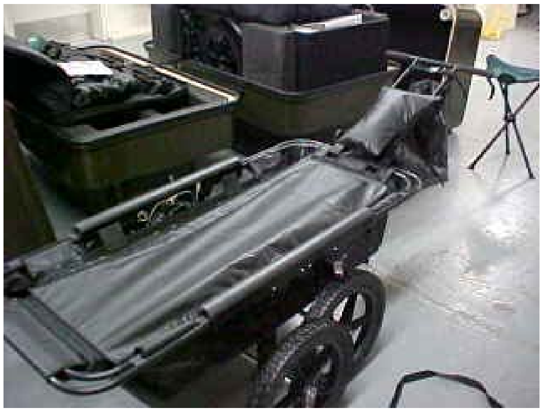
ASSEMBLY OF THE CH101M4 CART AXEL'S



ASSEMBLY OF THE CH101M4 FRAME

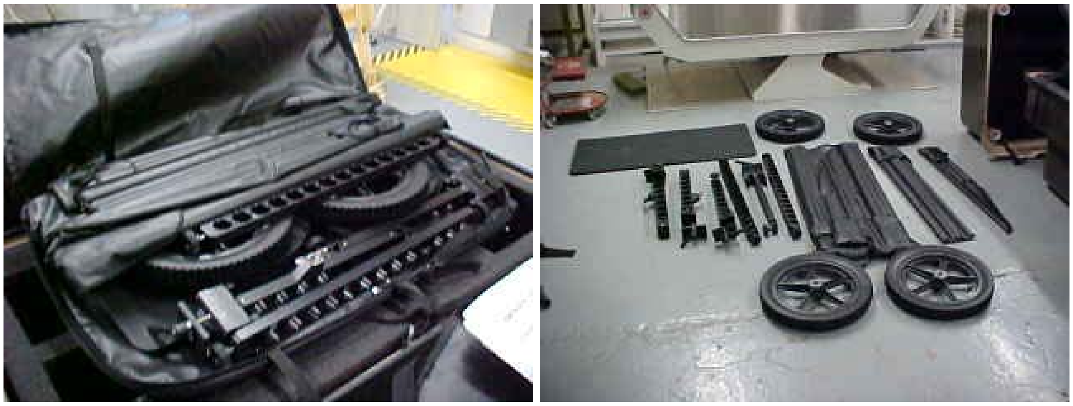




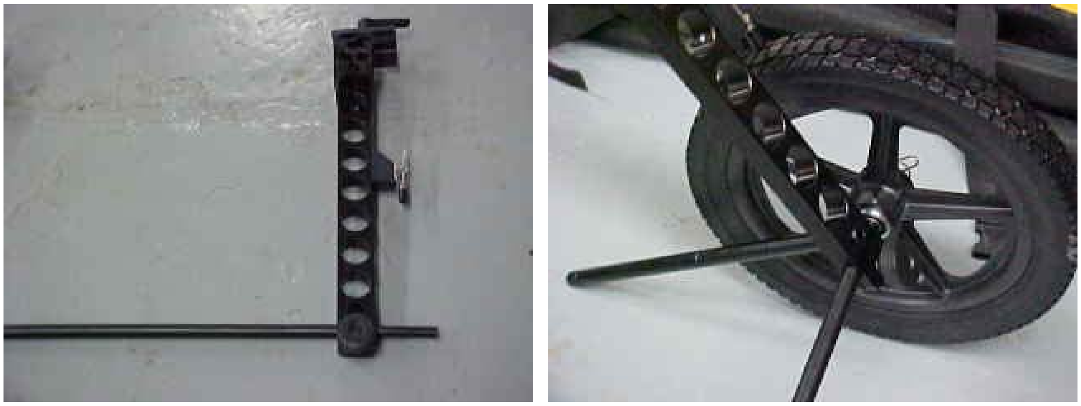


FINAL ASSEMBLY OF THE CH101M4

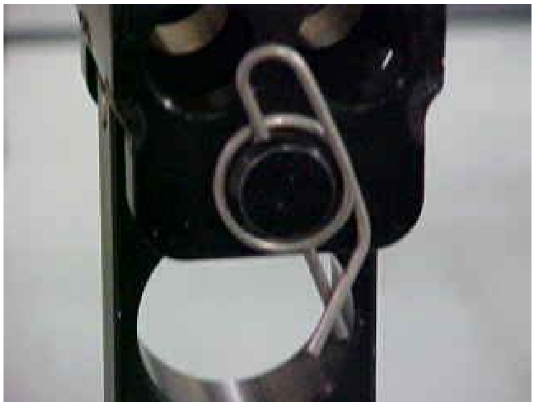
SR801RT CART

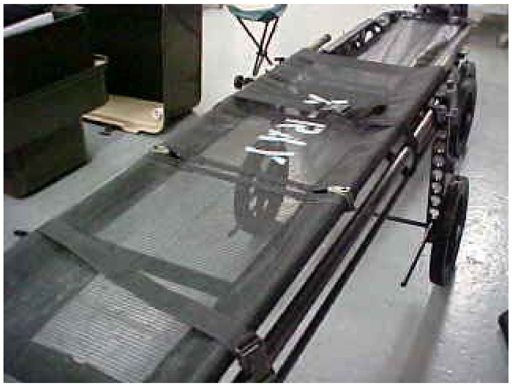


PART'S FOR THE SR801RT



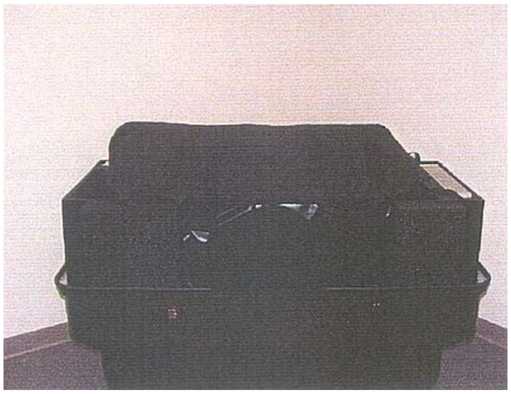
ASSEMBLY OF THE AXLE'S





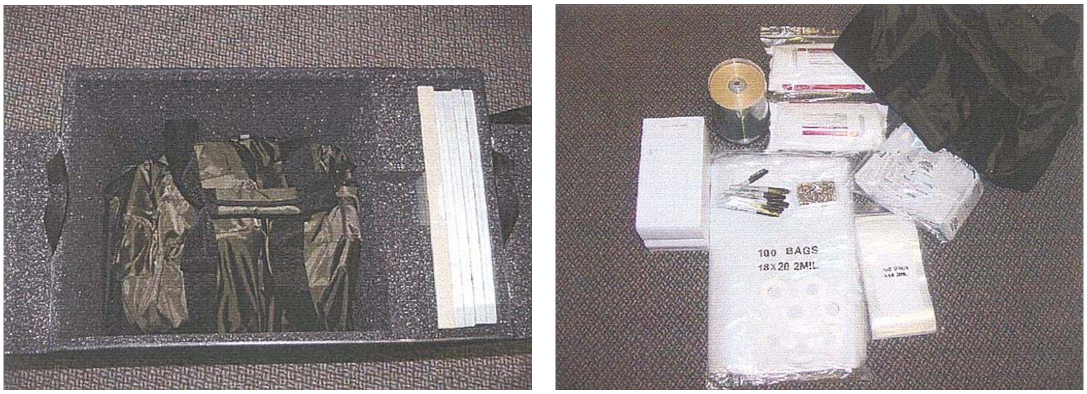
COMPLETE ASSEMBLY

CR2000ML COMPUTED RADIOLOGY SYSTEM

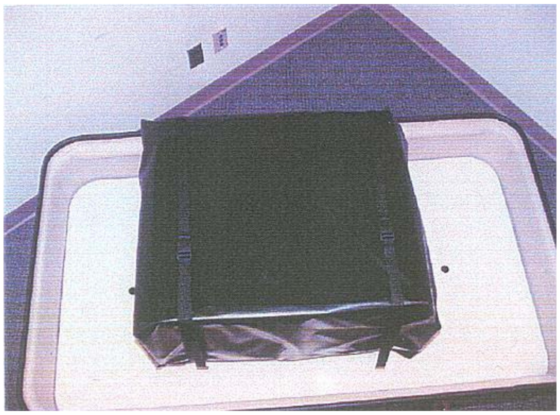


REMOVE COVER FROM CONTAINER A

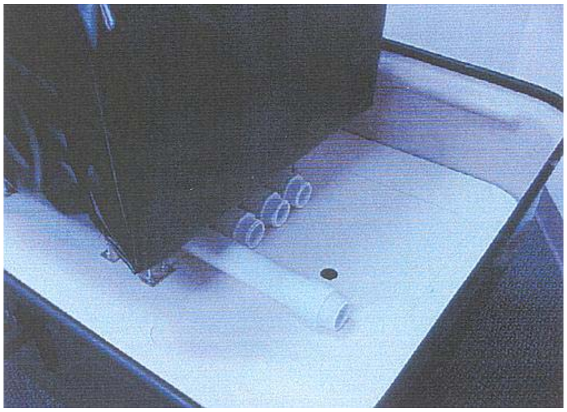
REMOVE PADDED FOAM ACCESSORY BINS


100 BAGS
18X20 2MIL

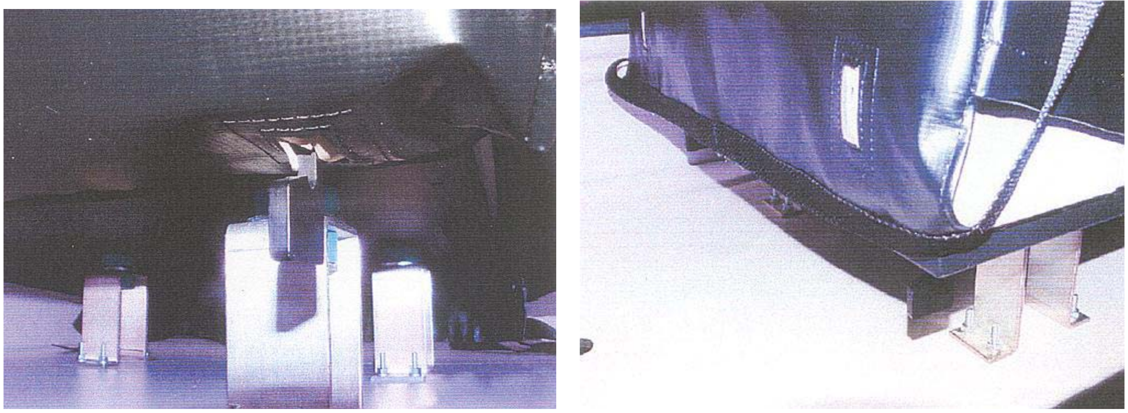
PADDED FOAM ACCESSORY BINS HOLDING CASSETTES,GRIDS AND CONSUMABLES



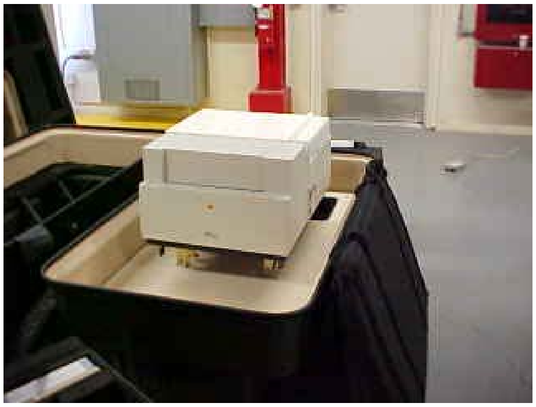
KODAK CR READER WITH DUST COVER IN PLACE (WHENEVER UNIT IS SHIPPED OR NOT IN USE THE DUSTCOVER SHOULD BE USED)

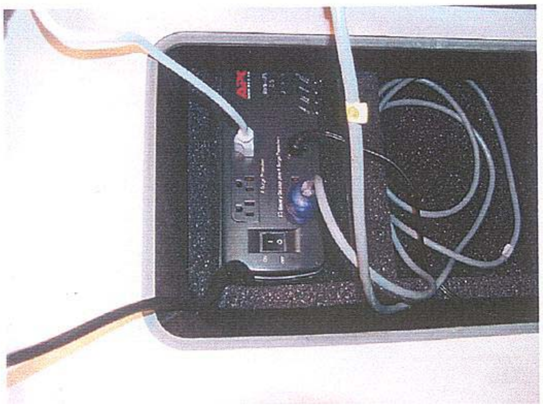


REMOVER 4 PVC LEGS FROM UNDERNEATH THE READER TO CONVERT THE COVER INTO A TABLE

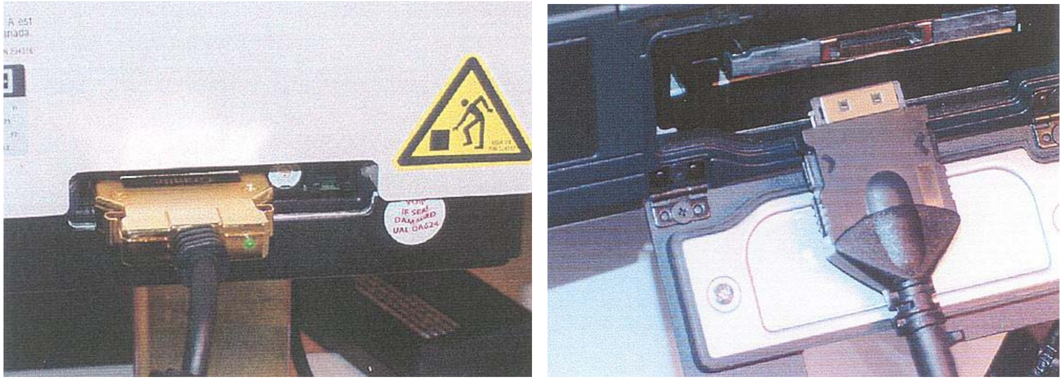


REMOVEL OF DUST COVER

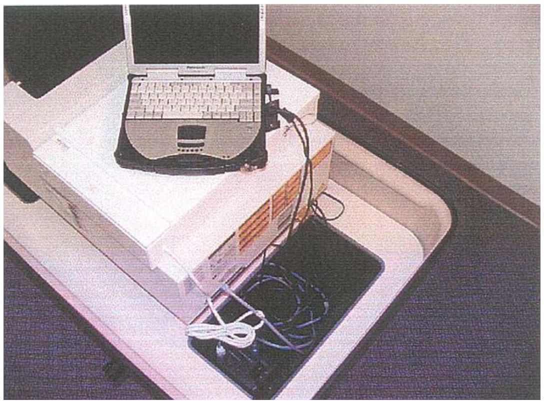


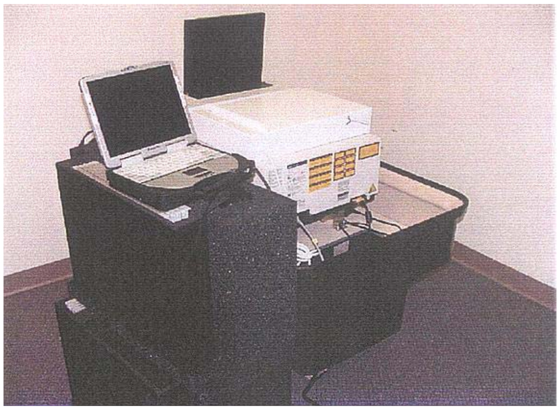


ELECTRIAL CONNECTION'S FOR THE CR READER (MAKE SURE THE UPS IS USED)



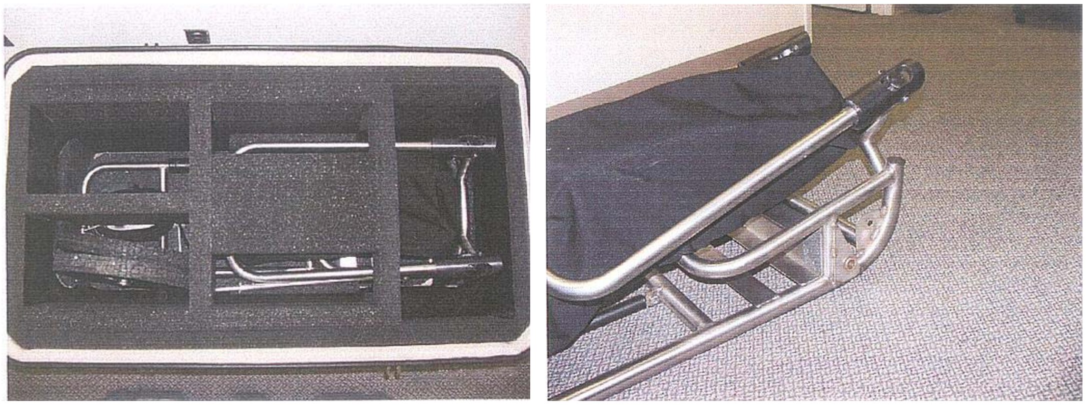
CONNECTING SCSI CABLE TO THE READER AND THE COMPUTER



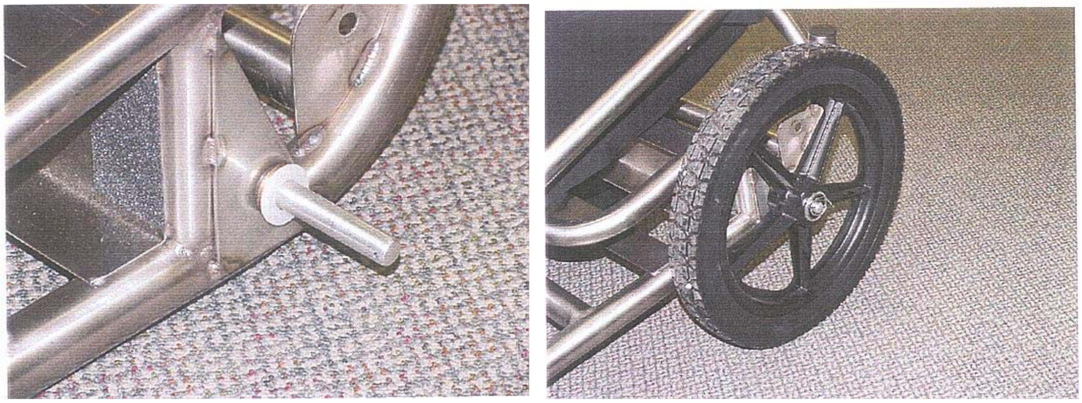


FINAL SETUP OF THE KODAK CR READER

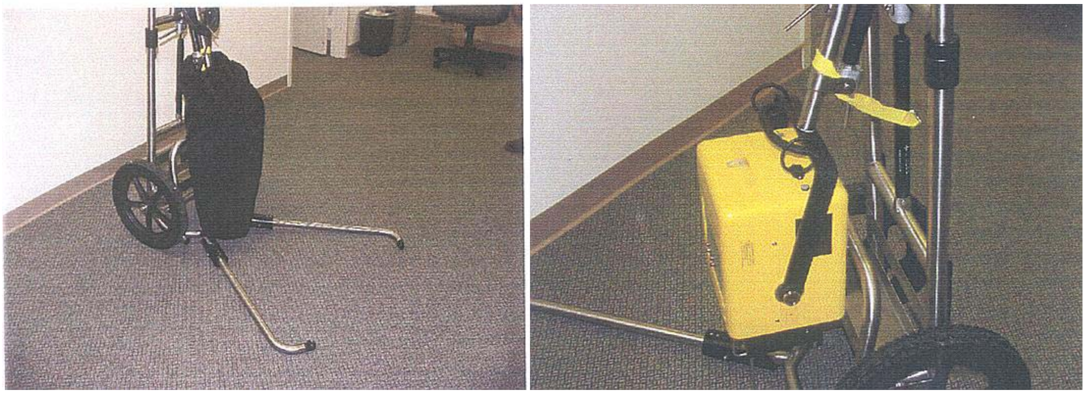
MINXRAY XRAY SYSTEM



REMOVE X-RAY SYSTEM FROM CONTAINER B



INSTALL WHEEL'S ON X-RAY STAND



REMOVE PROTECTIVE BAG AND REMOVE NYLON SAFTEY STRAP

ACR2000 CR SYSTEM SET UP GUIDE

SYSTEM SETUP

* Assembly the ACR2000 CR System (install IP tray & guide)& Minxray HF100H X-ray System (install axle and wheels).

* Connect the SCSI interconnect cable between the Computer and the CR System.

* Power up the ACR2000 CR System (plug in power cord and turn on) then turn the computer on.

Power up the computer

Note: The CR System must be turned on BEFORE the computer boot's up, for the computer to recognize the CR System.

* At the Windows 2000 login on screen:

LOGIN: Administrator
PASSWORD:

THERE IS NO PASSWORD JUST PRESS ENTER.

* Power Pacs will start automatically than it will ask for:

LOGIN: admin
PASSWORD: admin

Then you will need to minimize the Power Pacs application.

SCANNING A IMAGE PLATE

* Start the Kodak application by left clicking the Kodak Icon located on the desktop.

* When the Kodak application has finished loading enter a new patient. This can be done by clicking on the New Patient Icon on the Bottom right side of the screen. Then at a minimum enter the Patient Last Name and Patient ID. Then press the save button.

* Make a X-ray exposure of the Patient (the technique chart is on the back side of the x-ray stand).

* Darken the room, Take the exposed Image Plate out of the cassette and position the Image Plate on the feed slot of the ACR2000 with the white side of the Image Plate facing the feed guide.

* Click the scan icon on the preview window toolbar. The image window setup will be displayed. Select the body part and the grid removal option.

* When the scan is complete you will able to view the image by clicking on the thumbnail in the preview window.

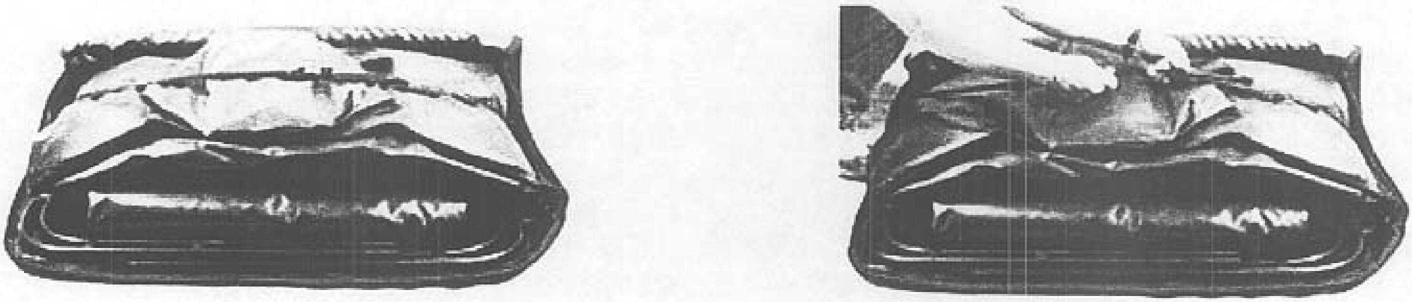
* Place the scanned image plate on the eraser with the white side facing toward the light's. Turn on for 40-sec. Then remove the Image Plate and place back in the cassette.

SENDING IMAGES TO POWER PACS

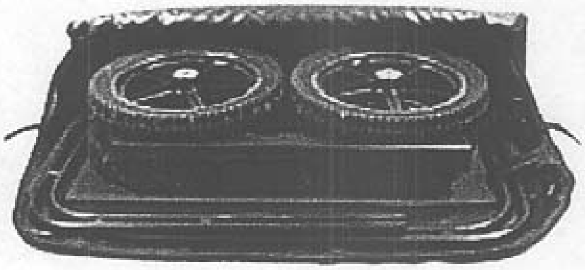
* Left click on the Power Pacs Node (bottom left side of the screen). Right click on the patient study (bottom right side of screen) select send images. This will send the images to Power Pacs application.

* Close the Kodak application and maximize the Power Pacs Application. The patient study you sent should be on the list of images to be copied(bottom of the screen). Insert new CD-R into the D: drive (CD-RW drive) and click on the CUT-CD button(bottom of the screen). When the cd is finished it will autoeject from the D: drive.

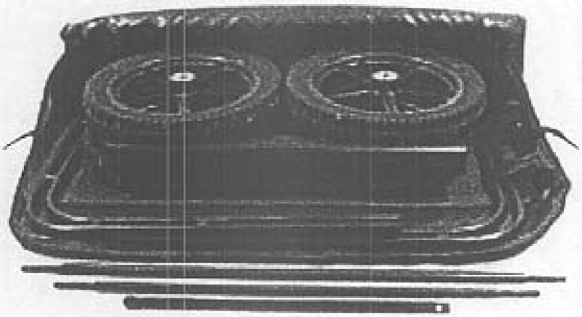
TECHNICAL MANUAL CH101M4



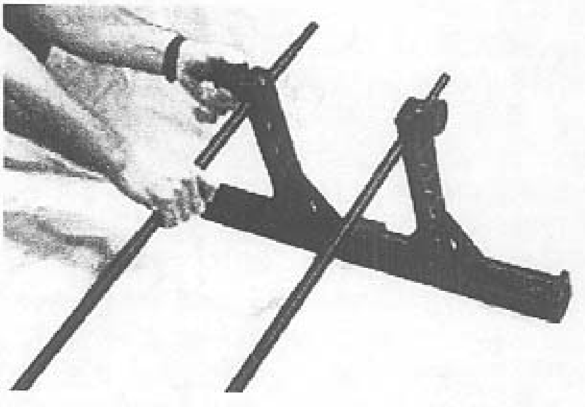
1. Remove Canvas Components, Axle Bag, and Handle from Carry Bag.



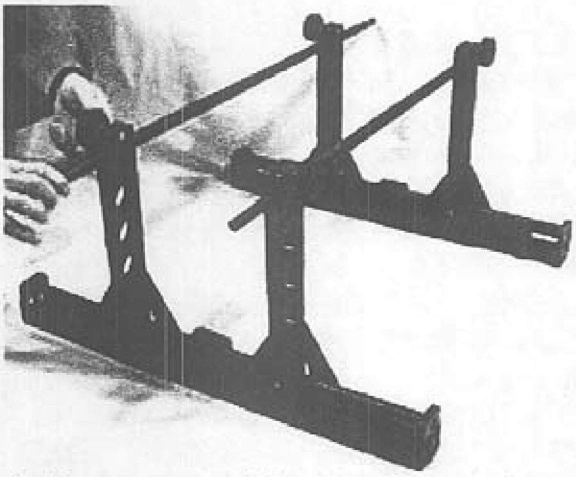
2. Take note of how CH101M4 is stored within Carry Bag. This information will be useful when breaking unit down



3. Remove components from Axle Bag: 2 Axles (36" and 31"), Kickstand, 4 Rue Pins, and 8 Release Pins. Place in front of unit as shown.



4. Remove remaining components from Carry Bag. Insert Axles into Stanchion as shown. Secure Axles within Stanchion at grooves located on Axles by tightening Stanchion Clamps.



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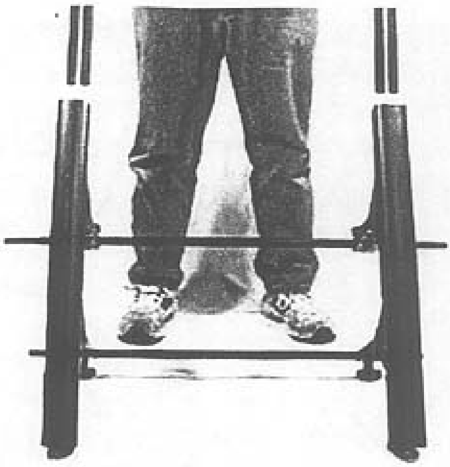
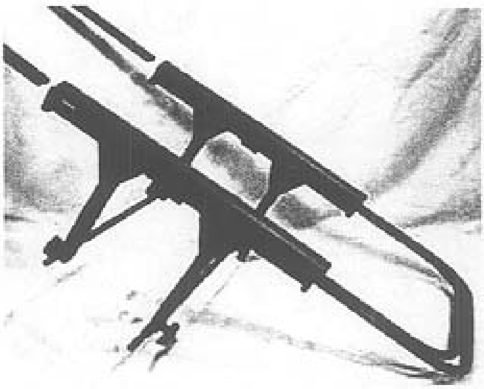
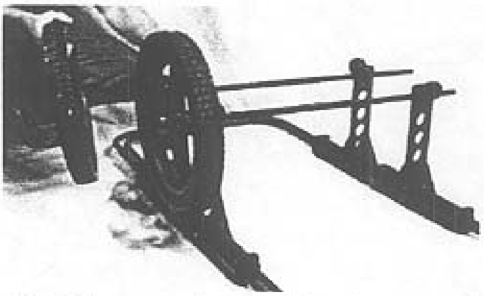


6. With 31" Axle facing downward insert Rear Frame as shown . (Note: Rear Frame does not have female handle receivers attached to it.) If Rear Frame does not slide into Stanchions easily, it may be necessary to loosen Stanchion Clamps to ease assembly.



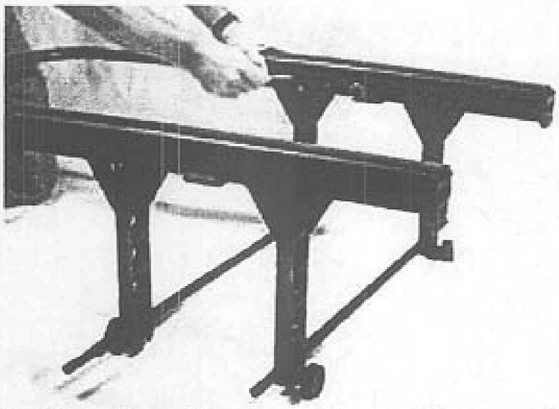
8. Placing unit as shown, insert Front Frame. If any resistance is encountered, again, merely loosen Stanchion Clamps.



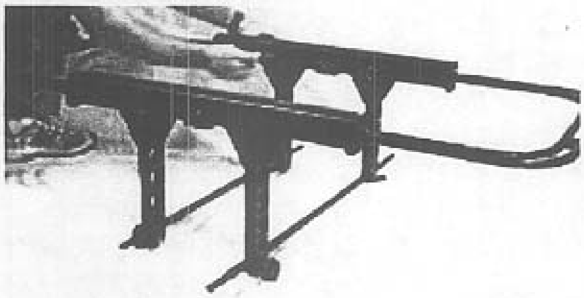
10. Place unit up-side down and install Wheels. (Note: Install Wheels to 31" Axle first and then to 36" Axle.)

Note:

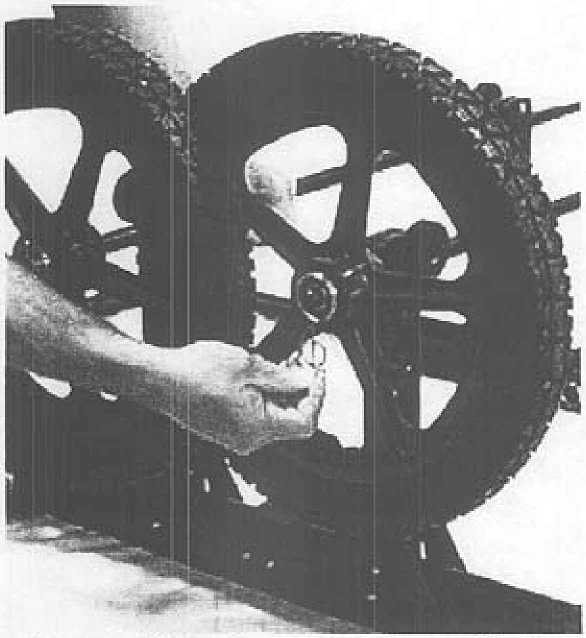
Occasional spraying of both front and rear frames with silicone spray will make assembly in Steps 6,7,8, and 9 much easier over time.



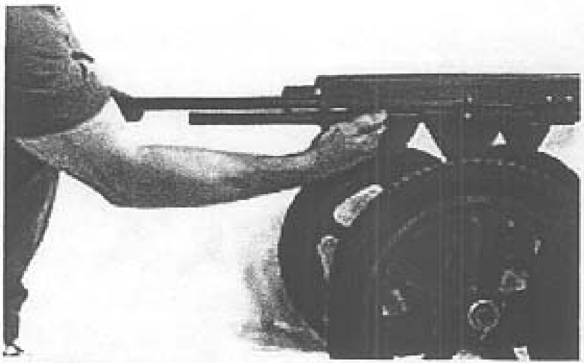
7. Once Rear Frame is installed, insert Release Pins as shown. Make sure you insert all 4 Release Pins.



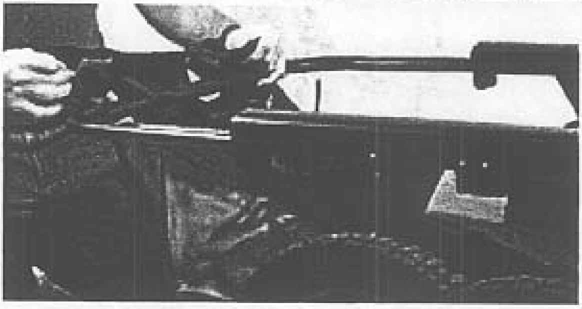
9. With Front Frame installed, insert Release Pins as shown. Again, making sure to install all 4 Release Pins.



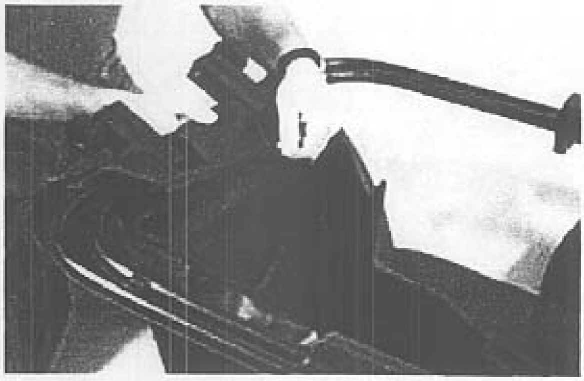
11. Secure Wheels onto Axles with Rue Pins, making sure Rue Pins face upward as shown. To install Rue Pins push into hole at end of Axle and they will snap secure. To remove Rue Pin, lift end of pin which has slight bend and pull.



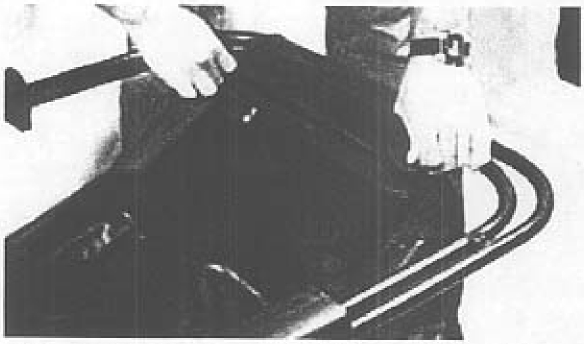
12. Remove Support Tubes located in Stanchions under the rail. (Note: Support Tubes are held in place by Stainless Steel Ball Plungers located within Stanchions.) Grab Support Tube securely and either pull or push to disengage Ball Plunger.



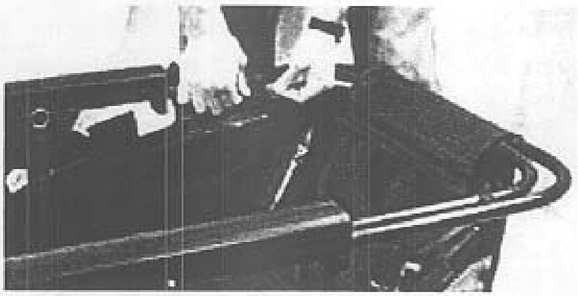
13. Place Wagon/Stretcher Canvas over female handle receivers located on Front Frame.



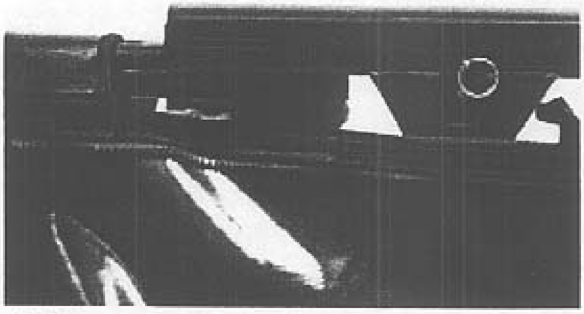
14. Secure by closing zipper as shown.



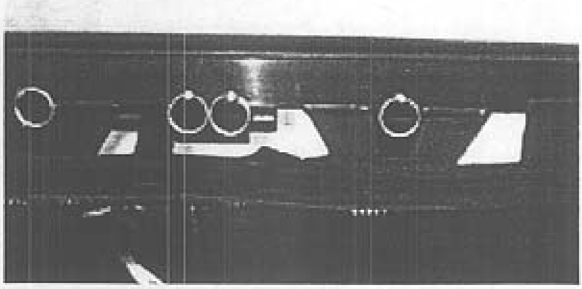
15. Place rear of Wagon/Stretcher Canvas over Rear Frame as shown and secure by closing zipper.



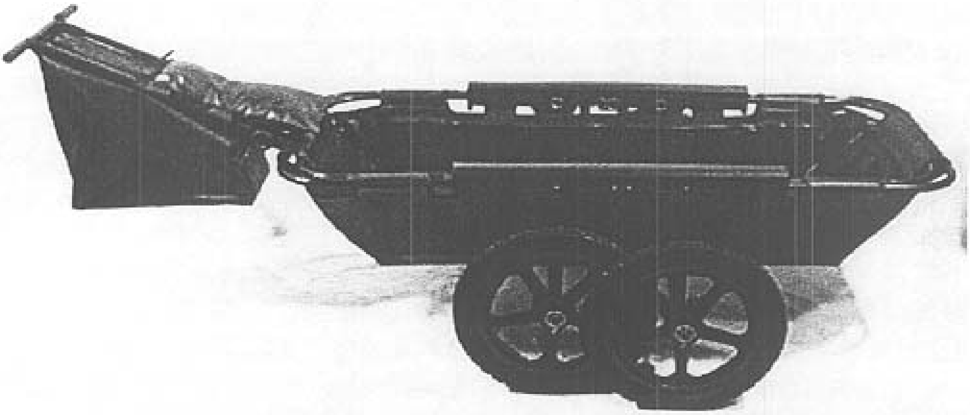
16. Secure remaining zippers located in all four corners.



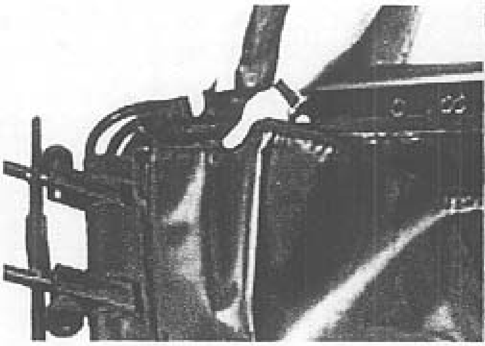
17. Replace Supports Tubes which were removed in Step 12. This is accomplished by slowly inserting Support Tube making sure it passes through all 4 loops located on each side of Wagon/Stretcher Canvas.



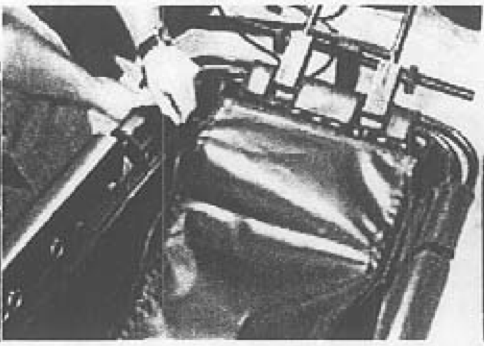
18. As stated in Step 17, make sure Support Tube passes through each of the 4 loops as shown..



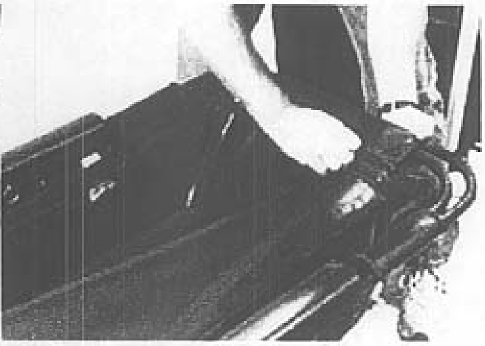
32. Unit is now configured as a Cargo Hauler



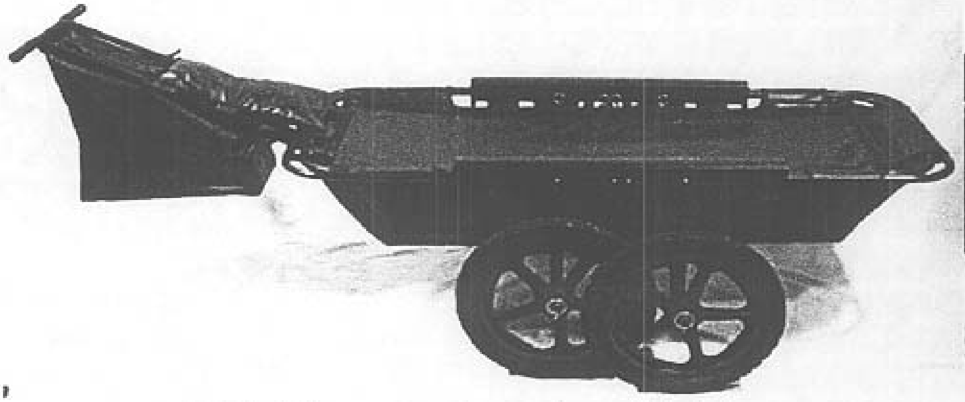
33. To configure as a Stretcher merely lift Stretcher Canvas from under Hard Polymer Bottom and fasten zippers.



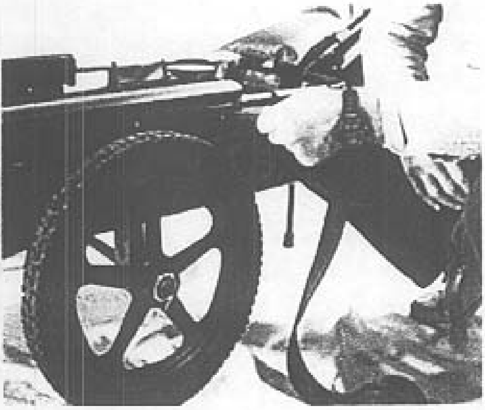
34. It is recommended that zippers be started, beginning with the right front, then progress to left front. Do not close zippers all the way at this point.



35. Fasten the rear zipper completely and return to both front zippers and close them.



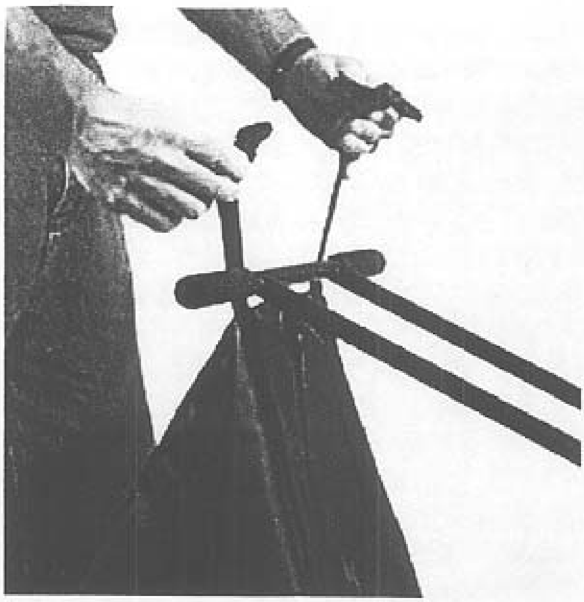
36. Unit is now configured as a Stretcher.



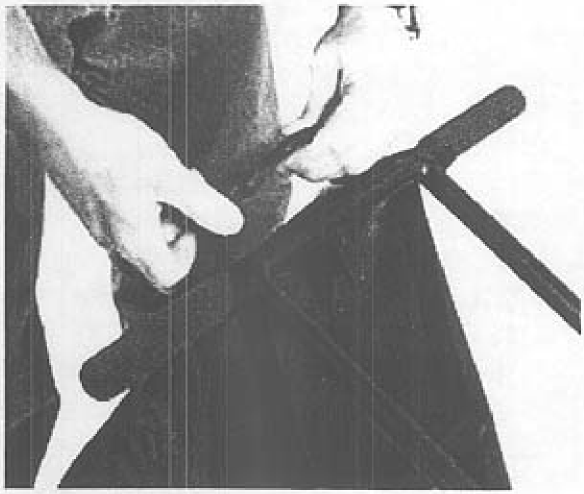
37. If straps are required to secure load, insert them through slots located at either end of the rails as shown.

Note: Exposure to saltwater requires rinsing with freshwater as soon as possible to assure product life. If unit is subjected to saltwater on a regular basis it is recommended that wheel bearings be sprayed with WD40 Lubricant.

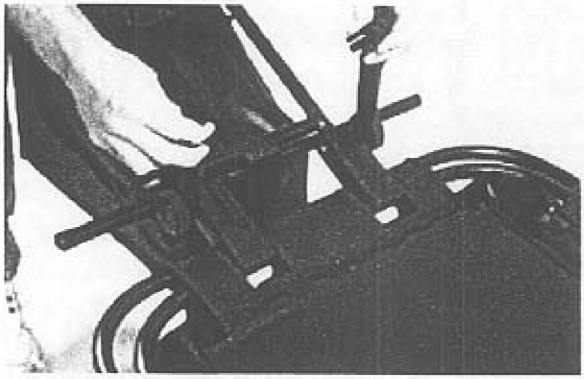
PATENTS 6,142,491 6,164,671, 6,270,092



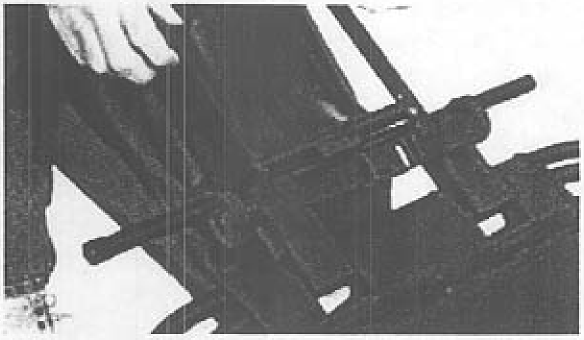
26. Install Cargo Bag by grasping straps located at top of bag and pass over the top of Handle as shown.



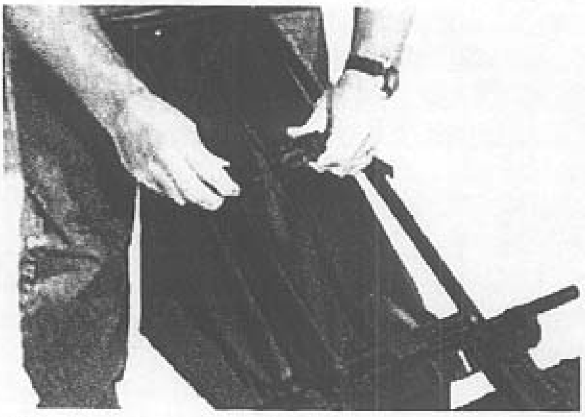
27. Pass straps under Handle and snap secure.



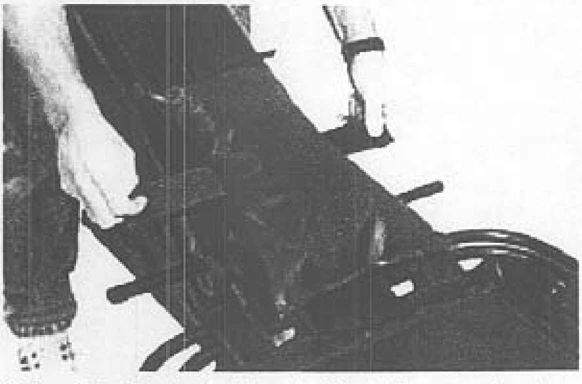
28. Secure rear of Cargo Bag by passing straps located at rear of bag behind Handle Knobs as shown.



29. Snap secure.

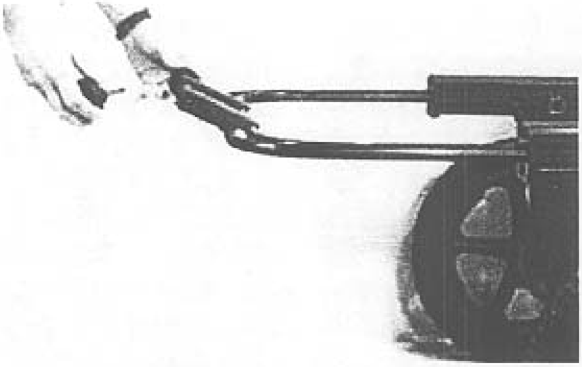


30. Secure remaining strap of Cargo Bag as shown.

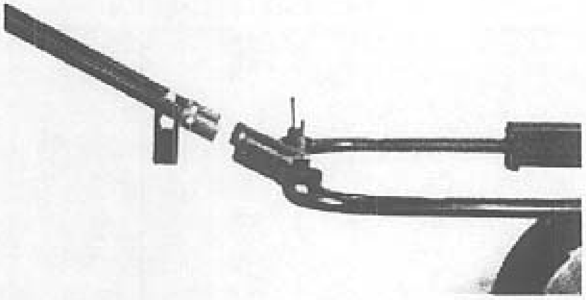


31. To install Head Cushion unfasten center strap of Cargo Bag and pass velcro straps attached to Head Cushion around Handle struts and secure. Refasten center strap of Cargo Bag.

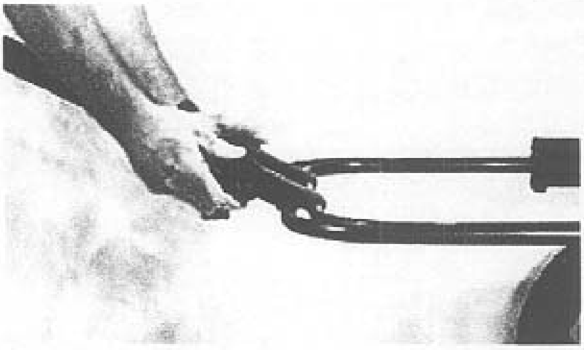
PATENTS 6,142,491 6,164,671, 6,270,092



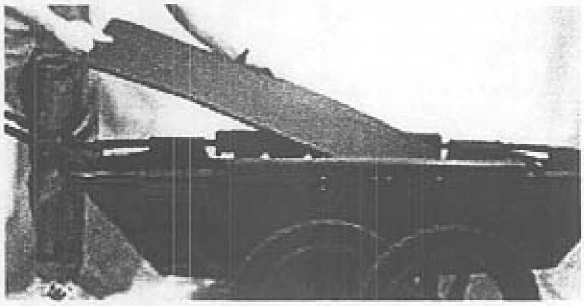
19. Remove Handle Knobs from female handle receivers.



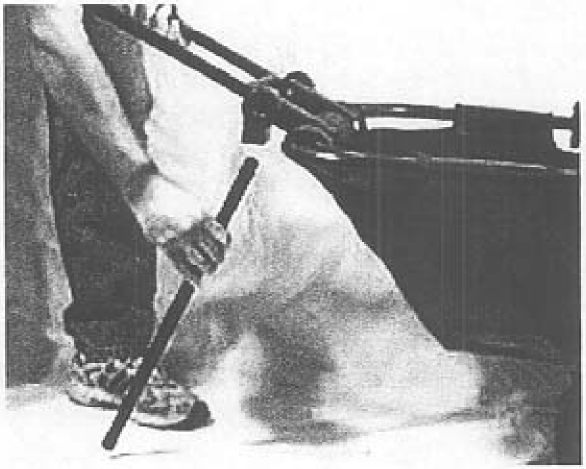
20. Insert Handle into receivers.



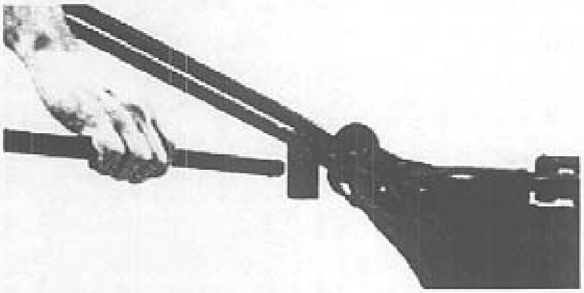
21. Secure Handle by replacing Handle Knobs and tightening as shown.



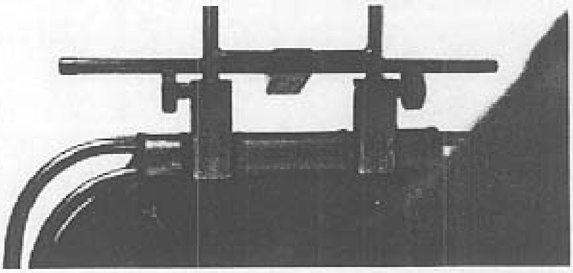
22. Insert Hard Polymer Bottom into unit.



23. Insert Kickstand into female receiver located at bottom of Handle.



24. Remove Kickstand once unit is loaded and store in horizontal storage hole located in female receiver prior to moving forward.



25. Kickstand properly stowed in Handle.

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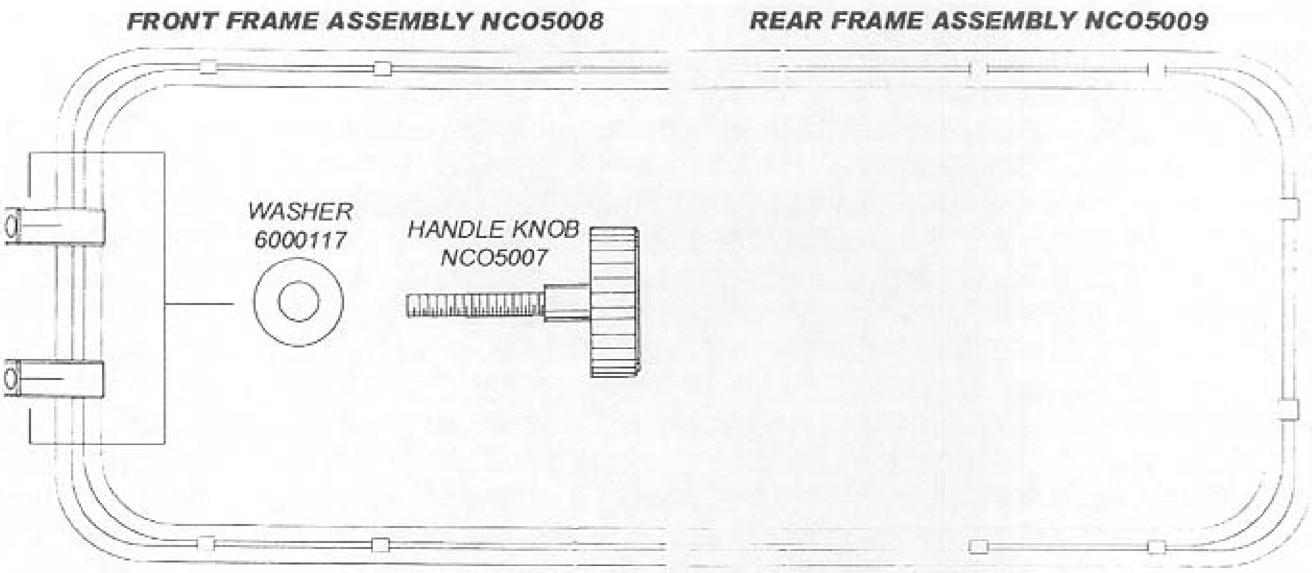
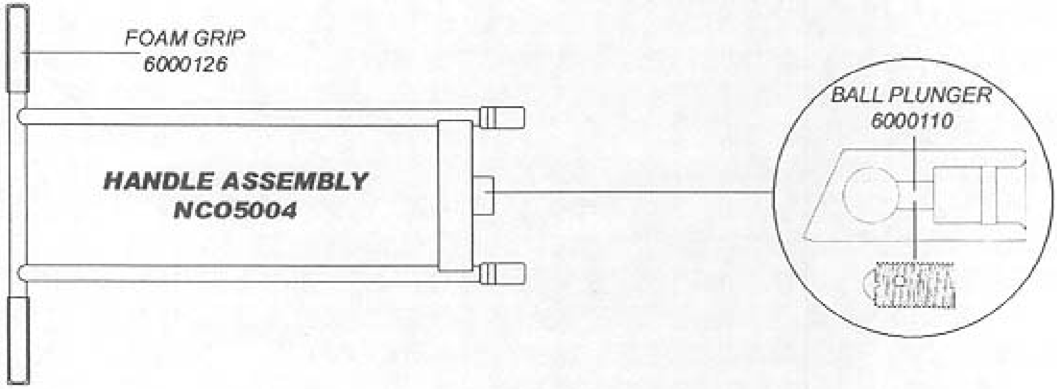
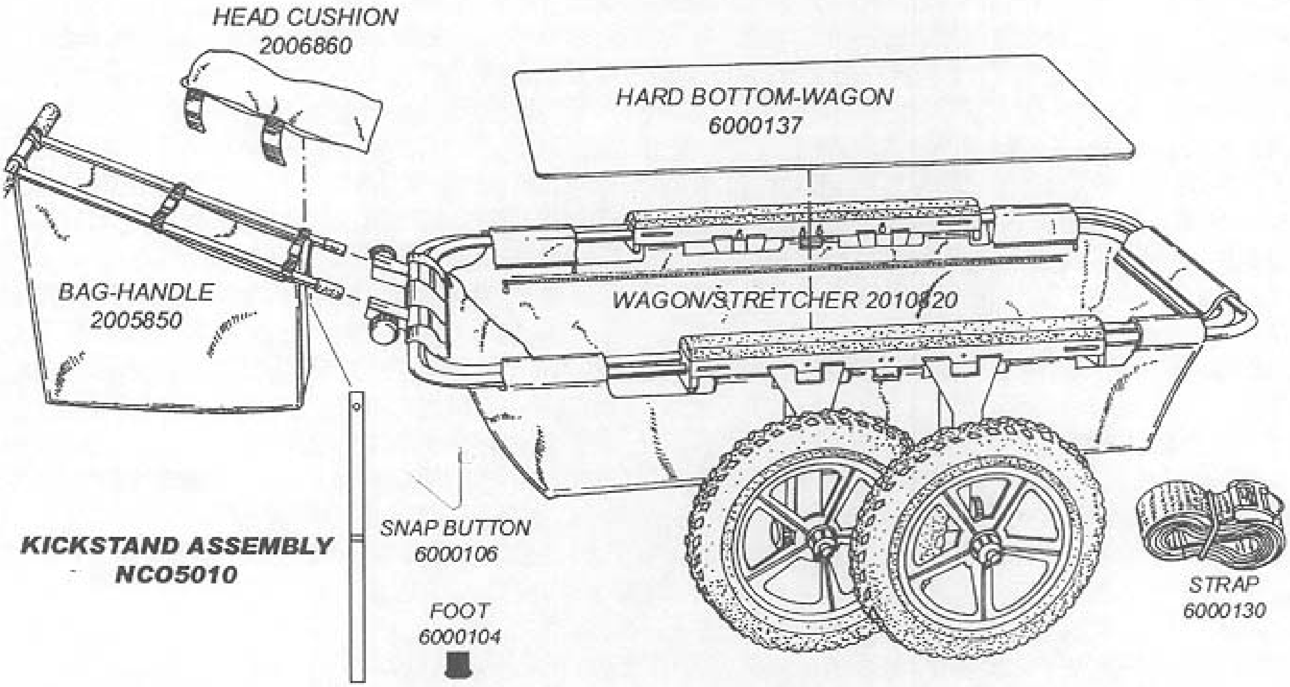

FRONT FRAME ASSEMBLY NCO5008
REAR FRAME ASSEMBLY NCO5009
WASHER
6000117
HANDLE KNOB
NCO5007


FOAM GRIP
6000126
HANDLE ASSEMBLY
NCO5004
BALL PLUNGER
6000110


HEAD CUSHION
2006860
HARD BOTTOM-WAGON
6000137
BAG-HANDLE
2005850
WAGON/STRETCHER 2010820
KICKSTAND ASSEMBLY
NCO5010
SNAP BUTTON
6000106
FOOT
6000104
STRAP
6000130

NOTE: *THE FOLLOWING COMPONENTS HAVE NOT BEEN ILLISTRATED; BAG-AXLE 2009811, BAG-CARRY 2037810, COVER-CARGO 2011840, AND HARD BOTTOM-HANDLE BAG 6000136.*

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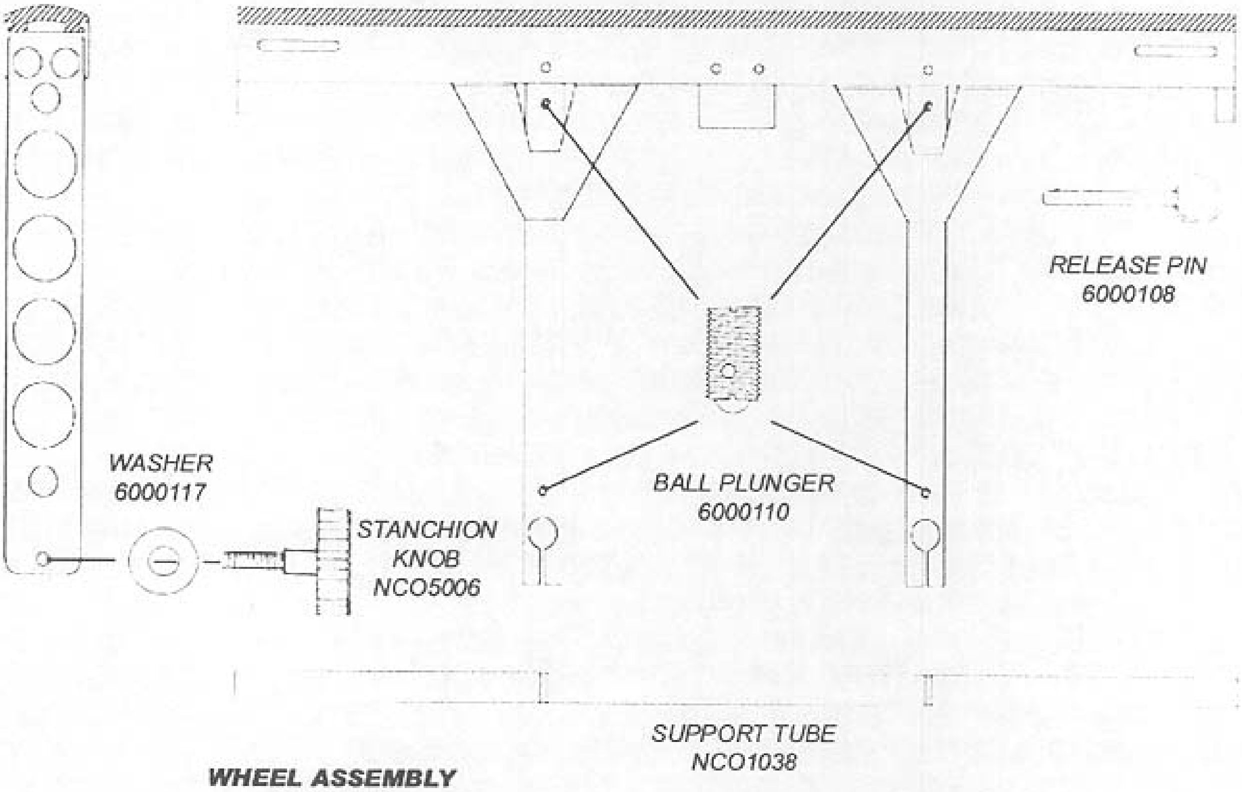
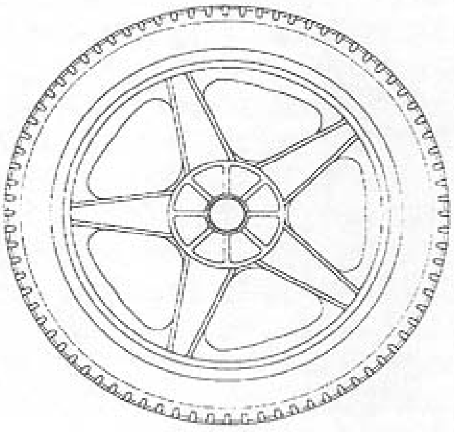
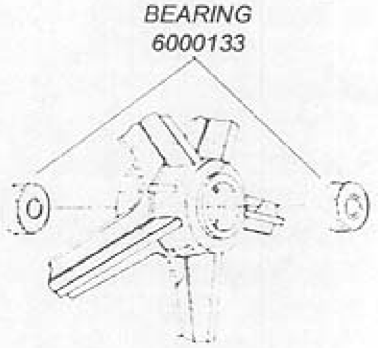
PARTS IDENTIFICATION

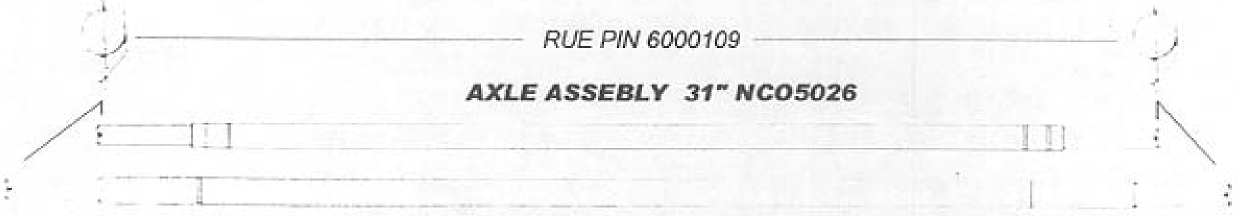
STANCHION ASSEMBLY
NCO5001


RELEASE PIN
6000108
WASHER
6000117
BALL PLUNGER
6000110
STANCHION
KNOB
NCO5006
SUPPORT TUBE
NCO1038

WHEEL ASSEMBLY
NCO5005




BEARING
6000133


RUE PIN 6000109
AXLE ASSEBLY 31" NCO5026

AXLE ASSEMBLY 36" NCO5027

PATENTS 6,142,491 6,164,671, 6,270,092

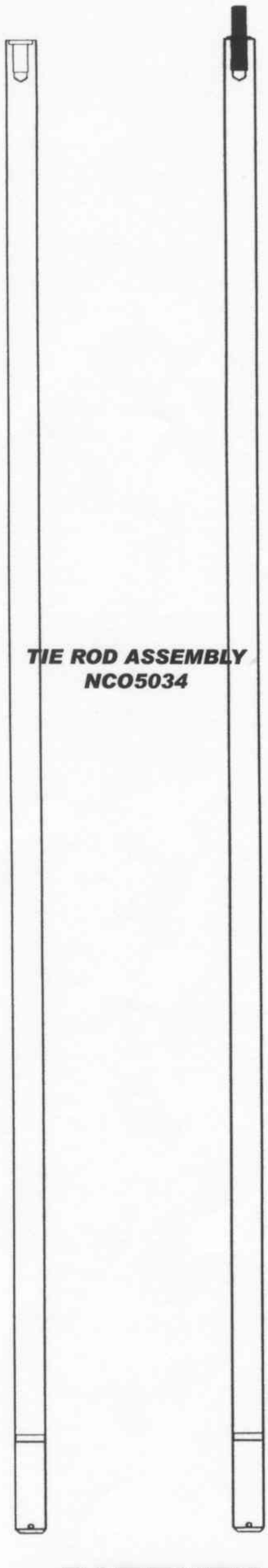
PRODUCT SPECIFICATIONS

Model :	CH101M4	Finish :	Black Anodized		
Weight :	58 Pounds	Fabric :	18.oz Shelter Rite		
Capacity :	500 Pounds	Components :	Stainless Steel		
Frame :	6061-T6 Aluminum		Height	Width	Length
Chassis :	6061-T6 Aluminum	Collapsed Bagged :	8"	26"	44"
Wheels :	Fiberglass Reinforced Nylon	Assembled / Overall :	21"	36"	77"
Tires :	16" X 2" Micro-cellular Urethane	Wagon :	10"	22"	56"
Bearings :	Sealed 440 Stainless Steel	Stretcher / Headrest :	21"	22"	70"

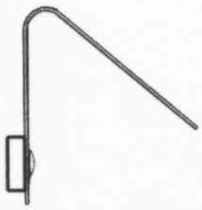
PARTS LIST

PART #	QTY	DESCRIPTION	MATERIAL
NCO5001	2	**STANCHION ASSEMBLY**	6061-T6 ALUMINUM
6000110	4	BALL PLUNGER	STAINLESS STEEL
6000108	8	RELEASE PIN	STAINLESS STEEL
6000117	4	WASHER	STAINLESS STEEL
NCO5006	4	STANCHION KNOB	POLYMER
6000129	2	BUMPER	PVC
NCO1038	2	SUPPORT TUBE	6061-T6 ALUMINUM
NCO5008	1	**FRONT FRAME ASSEMBLY**	6061-T6 ALUMINUM
6000117	2	WASHER	STAINLESS STEEL
NCO5007	2	HANDLE KNOB	POLYMER
NCO5009	1	**REAR FRAME ASSEMBLY**	6061-T6 ALUMINUM
NCO5004	1	**HANDLE ASSEMBLY ***	6061-T6 ALUMINUM
6000110	1	BALL PLUNGER	STAINLESS STEEL
NCO0014	2	BUSHING	PVC
6000126	2	FOAM GRIP	CLOSED CELL FOAM
NCO5010	1	**KICKSTAND ASSEMBLY**	6061-T6 ALUMINUM
6000106	1	SNAP BUTTON	STAINLESS STEEL
6000104	1	FOOT	RUBBER
NC05026	1	**AXLE ASSEMBLY 31"**	STAINLESS STEEL
6000109	2	RUE PIN	STAINLESS STEEL
NC05027	1	**AXLE ASSEMBLY 36"**	STAINLESS STEEL
6000109	2	RUE PIN	STAINLESS STEEL
NCO5005	4	**WHEEL ASSEMBLY**	NYLON/FIBERGLASS
6000133	8	BEARING	STAINLESS STEEL
6000134	4	TIRE	URETHANE
6000130	2	**STRAP**	POLYPRO
		CANVAS COMPONENTS	
2009811	1	BAG-AXLE	18 .oz SHELTER RITE
2037810	1	BAG-CARRY	1000 DENIER NYLON
2005850	1	BAG-HANDLE	18 .oz SHELTER RITE
2010820	1	WAGON/STRETCHER	18 .oz SHELTER RITE
2011840	1	COVER-CARGO	18 .oz SHELTER RITE
2006860	1	HEAD CUSHION	18 .oz SHELTER RITE
6000137	1	HARD BOTTOM-WAGON	POLYMER
6000136	1	HARD BOTTOM-HANDLE BAG	POLYMER

PATENTS 6,142,491 6,164,671, 6,270,092

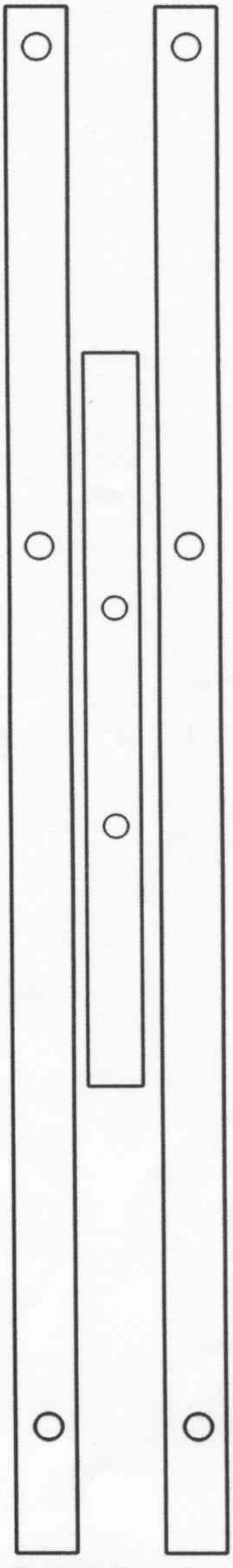


TIE ROD ASSEMBLY
NCO5034

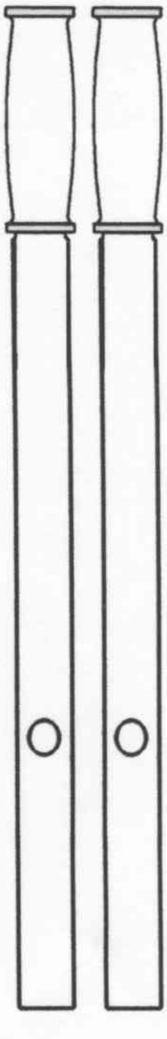


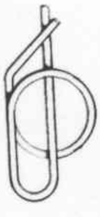
STAINLESS STEEL
SNAP BUTTON
6000144

SUPPORT TUBE
ASSEMBLY
NCO5033



HANDLE
SUB-ASSEMBLY
NCO5032





RUE PIN
6000109

NOTE:
SUPPORT TUBE ASSEMBLY
NCO5033 INCLUDES
2 HANDLE SUB-ASSEMBLYS
NCO5032

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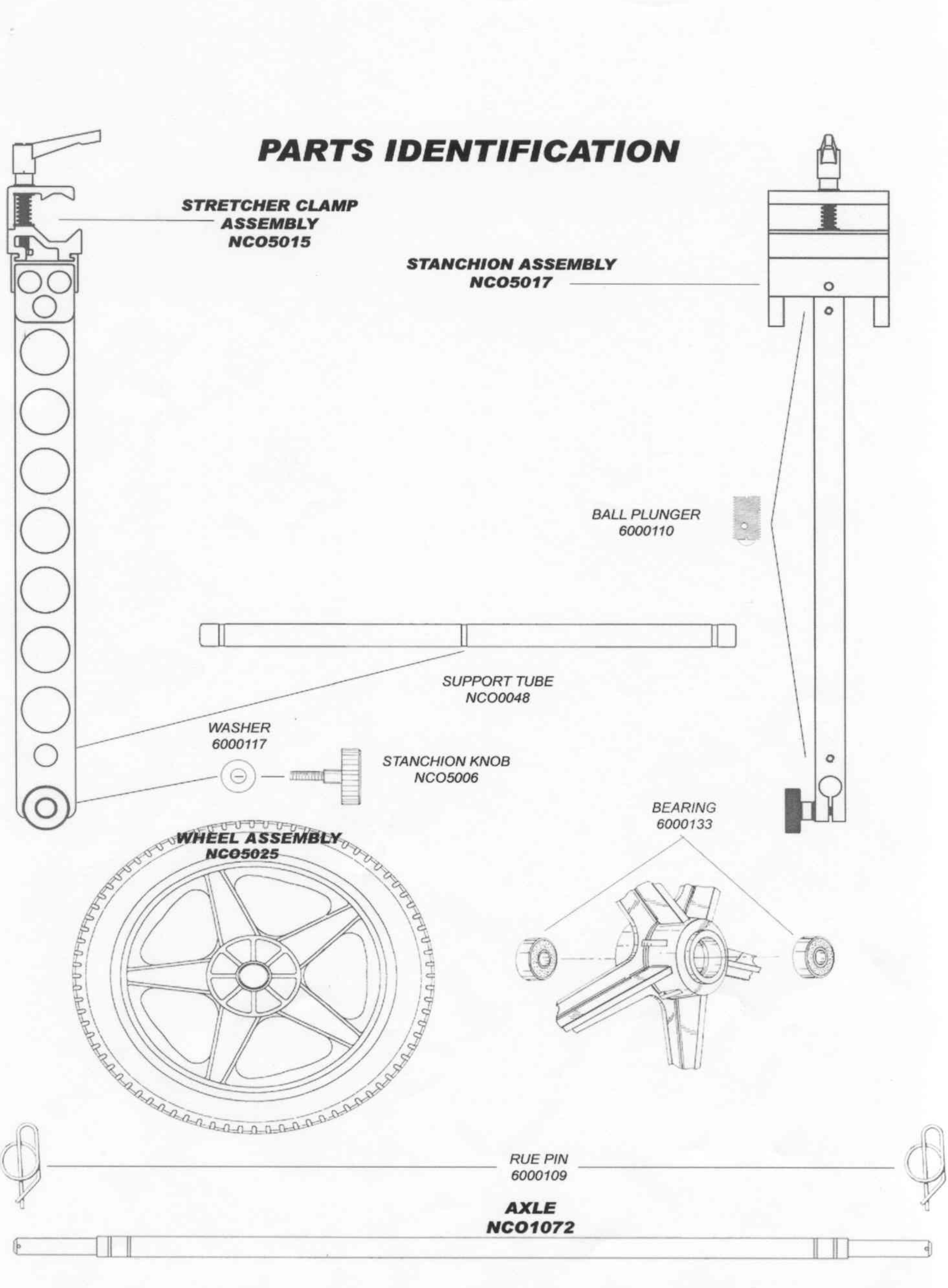
PARTS IDENTIFICATION


STRETCHER CLAMP ASSEMBLY
NCO5015
STANCHION ASSEMBLY
NCO5017
BALL PLUNGER
6000110
SUPPORT TUBE
NCO0048
WASHER
6000117
STANCHION KNOB
NCO5006
BEARING
6000133
WHEEL ASSEMBLY
NCO5025
RUE PIN
6000109
AXLE
NCO1072

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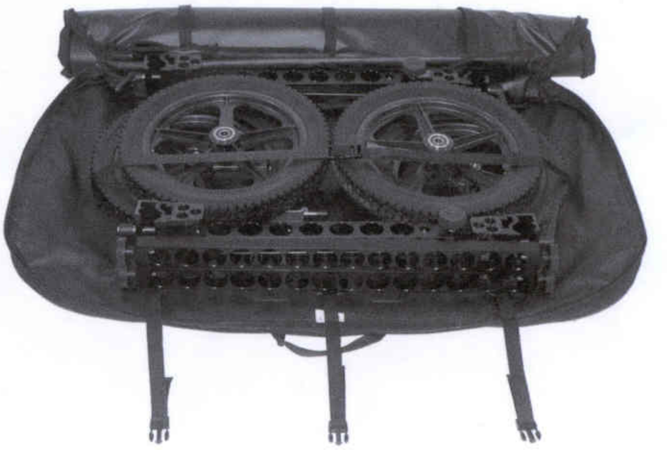
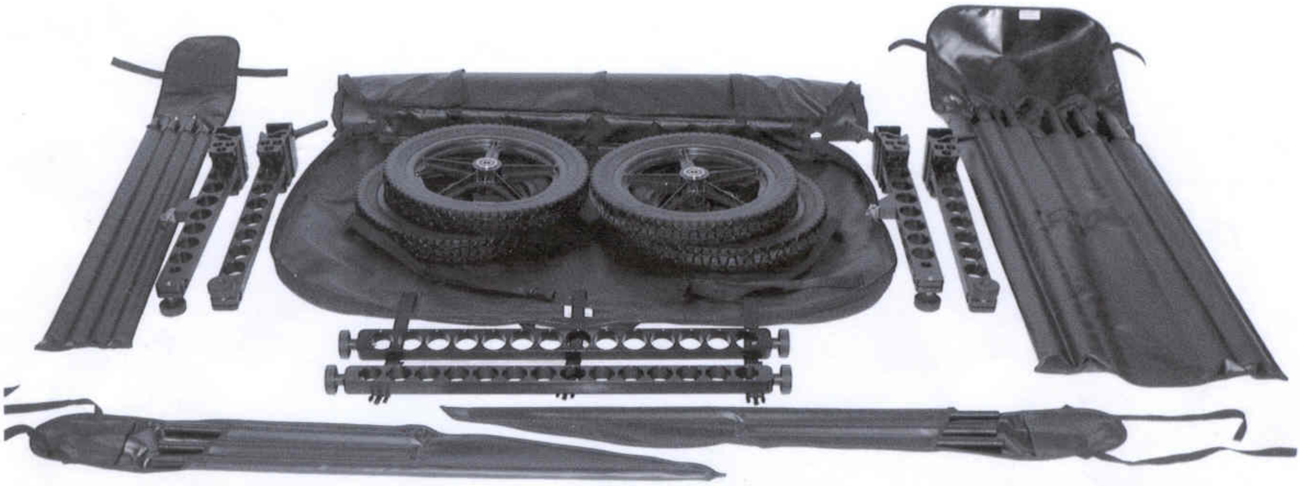
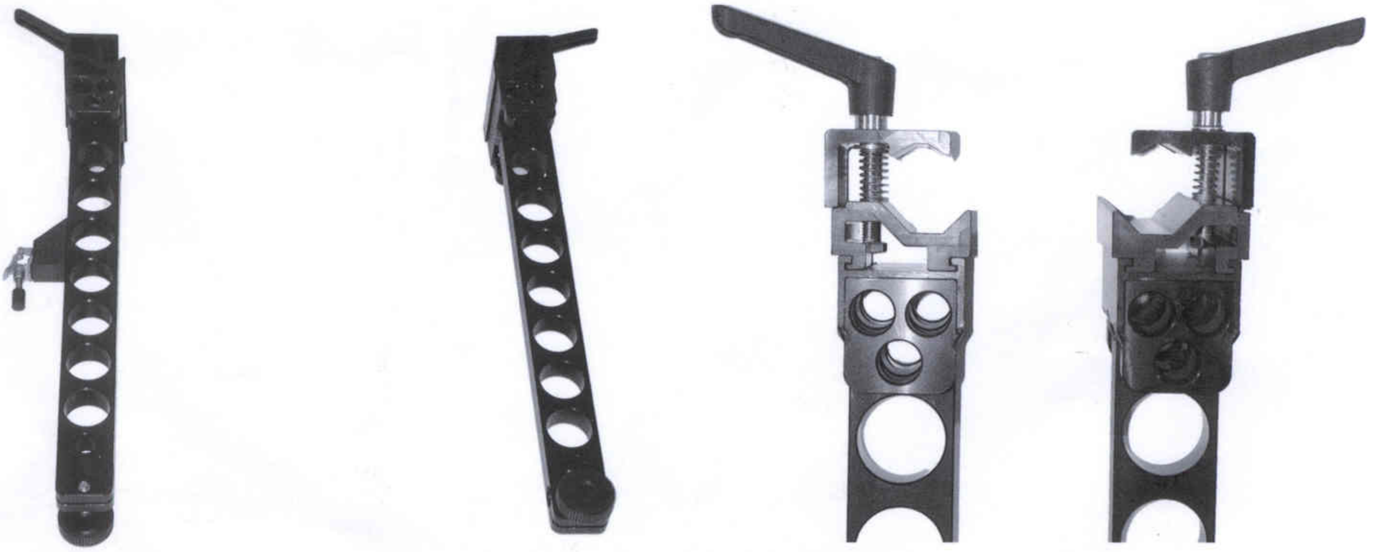
TECHNICAL MANUAL SR801RT

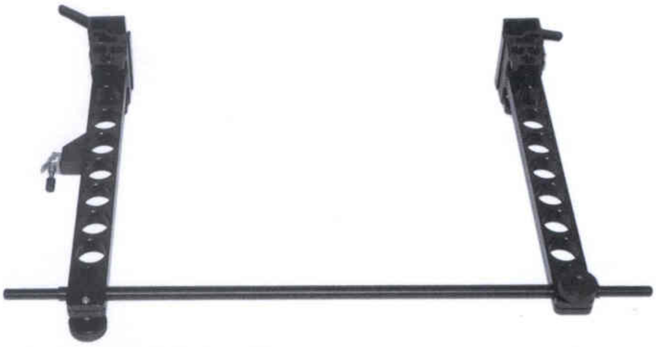


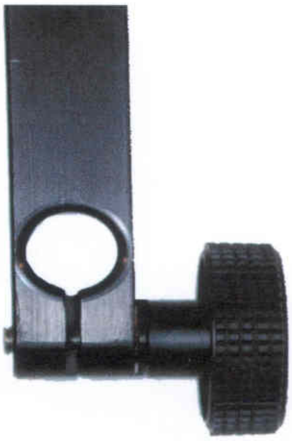


1. Remove components from Carry Bag.

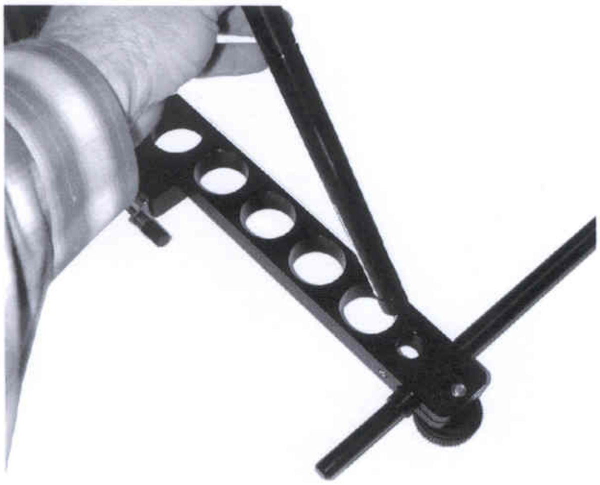


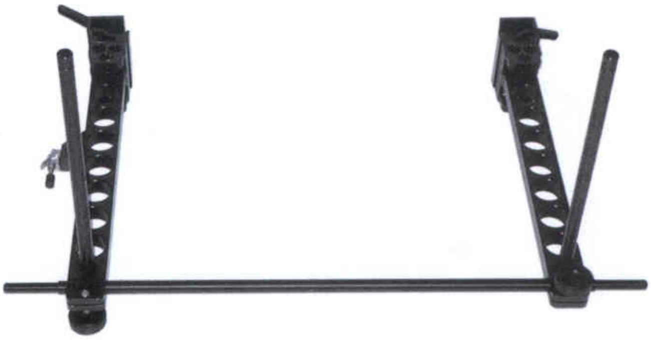
2. Place Stanchions as shown (Note: Stretcher Clamps atop, Stanchions should face inboard).



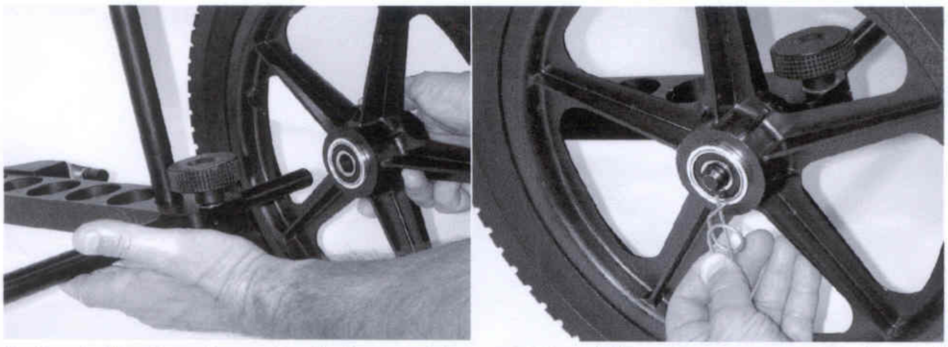


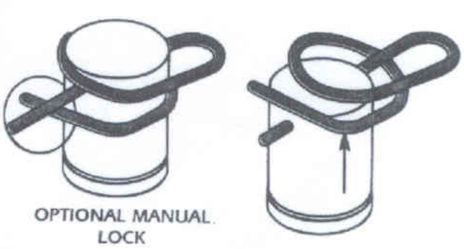
3. Insert Axle into Stanchions to groove on Axle and secure (Note: Axle is inserted into 3/4" hole.) →





4. Insert Kickstands into 3/4" hole located at bottom of stanchions directly over axle until engaged by stainless steel ball plunger (Approx. 1").





5. Install wheels onto Axle and insert Rue Pins to secure. To install Rue Pins push into hole at end of Axle and they will snap secure. To remove Rue Pins Lift end of pin which has slight bend and pull. To lock Rue Pin in place activate optional manual lock as illustrated.

6. Wheel assembly is now complete; repeat steps 2 thru 5 again for second wheel assembly.

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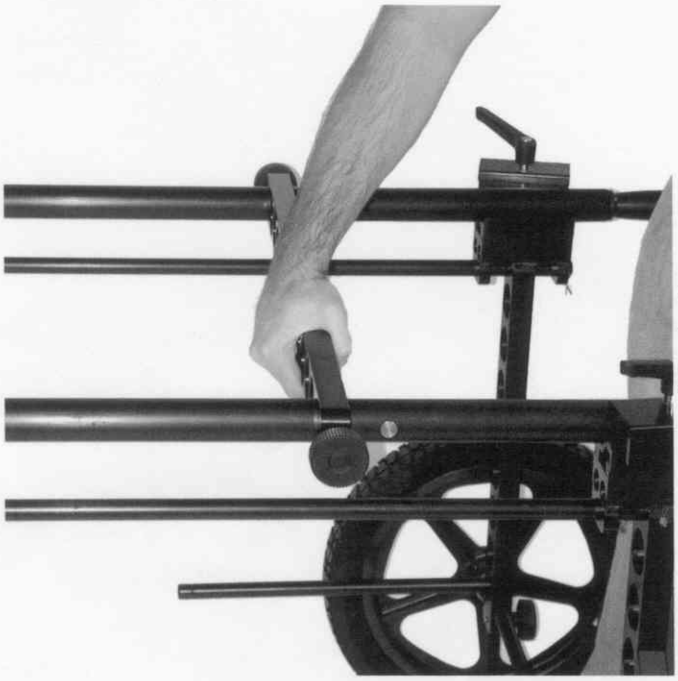
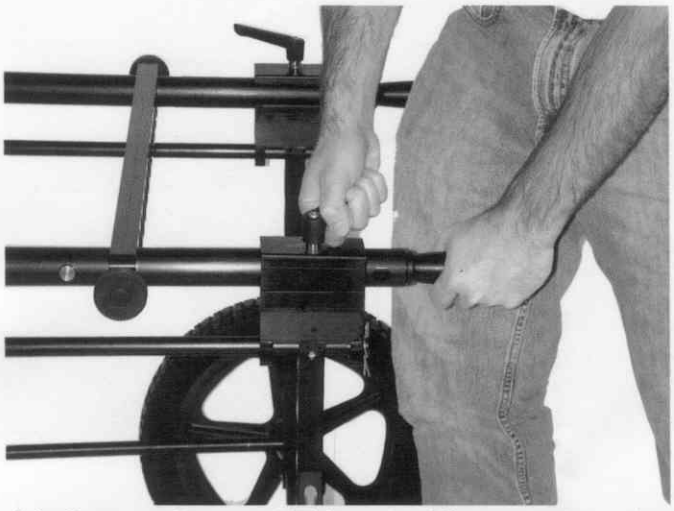
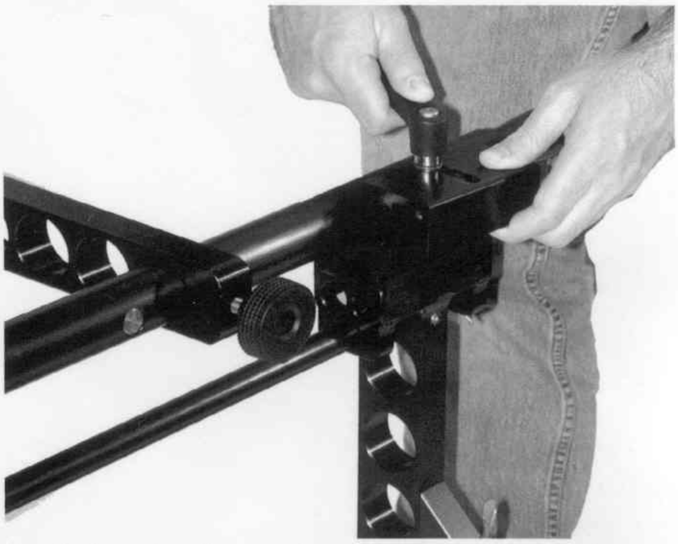
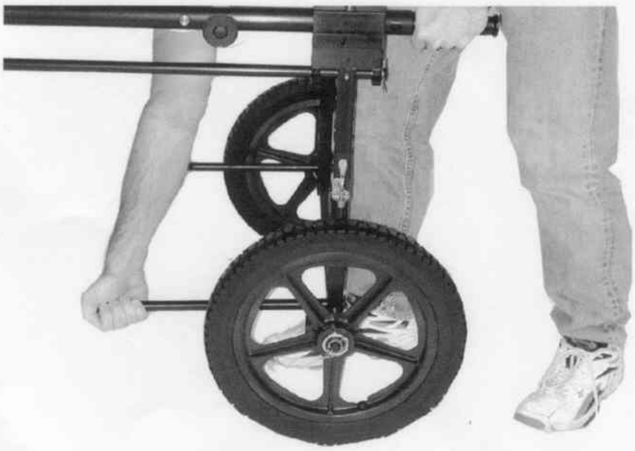


13 Take Cross Members and slide onto Support Tubes (Note: Support Tube are inserted in outer holes in Cross Members.





14. Secure Support Tubes to Clamps atop stanchions by tightening lever atop clamps (Note: To position lever after tightening merely lift lever while depressing stainless steel button. This will allow user to position lever wherever he chooses).



15. Slide Kickstands into Stanchions until they lock secure (half way).

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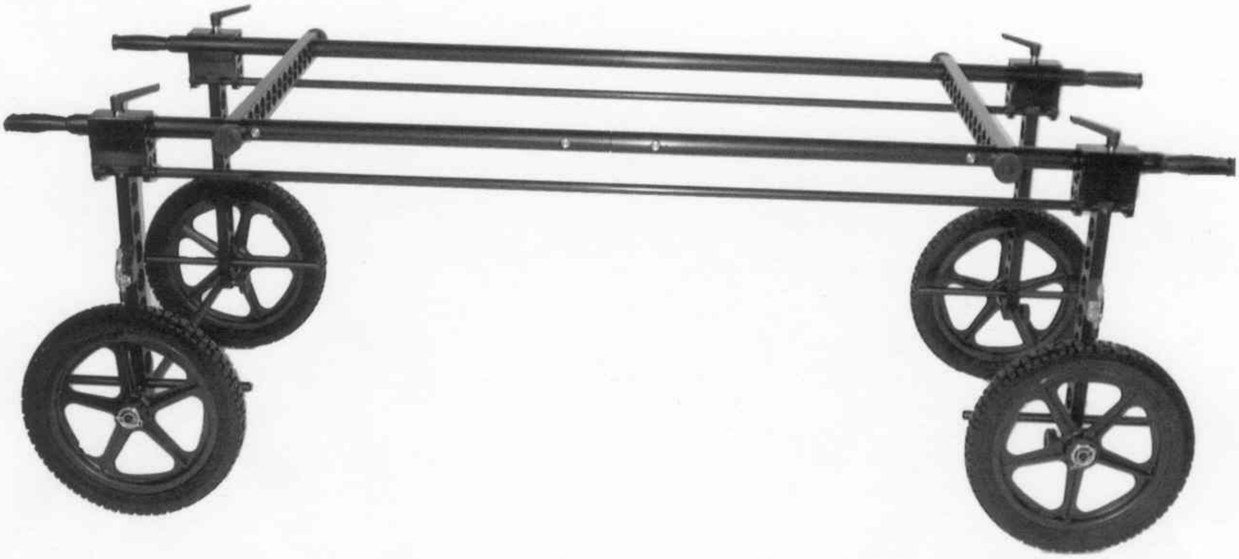
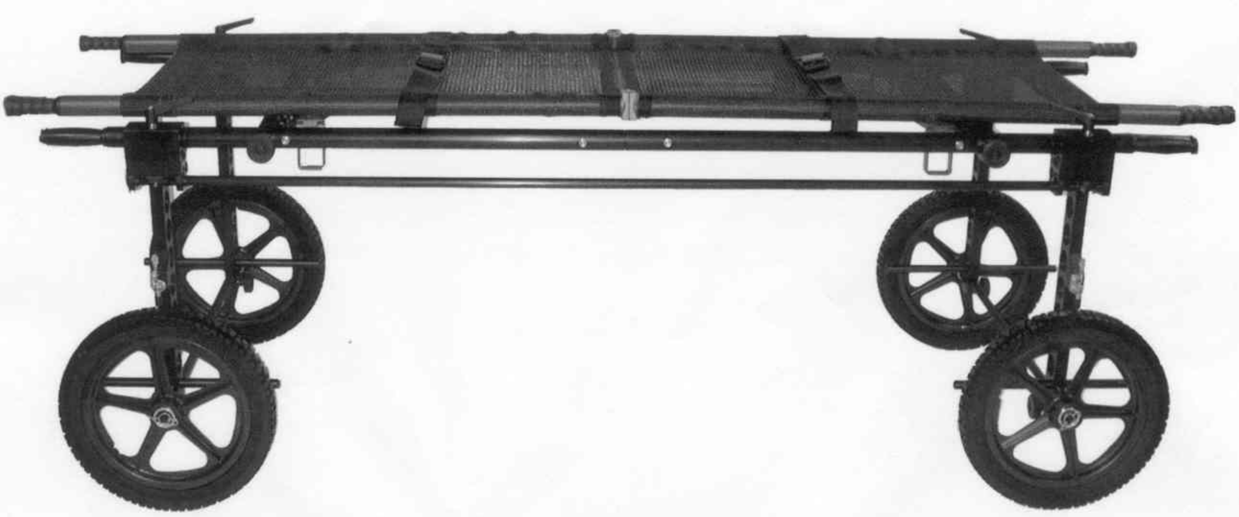
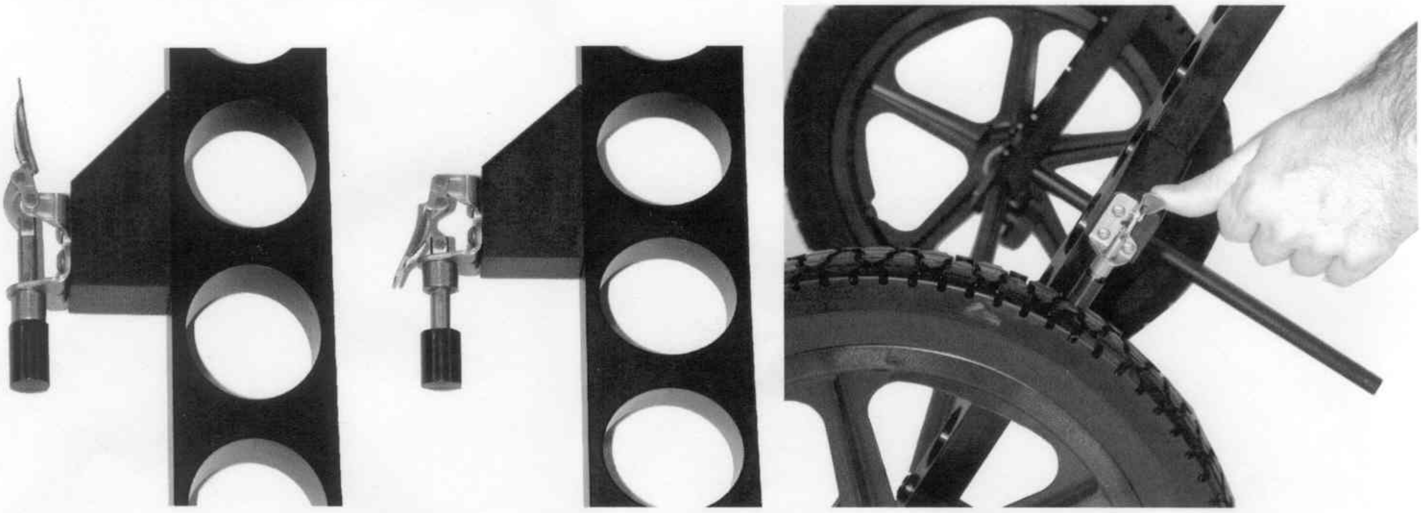


16. SR801RT is now assembled and ready to receive stretcher.



17. SR801RT shown with Raven Stretcher.



18.SR801RT Brake detail. To activate Break press down as illustrated above.

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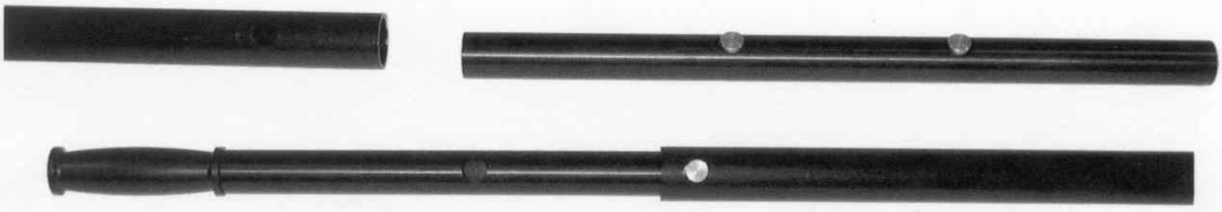
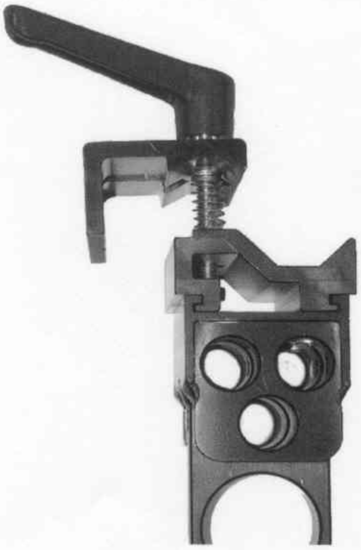
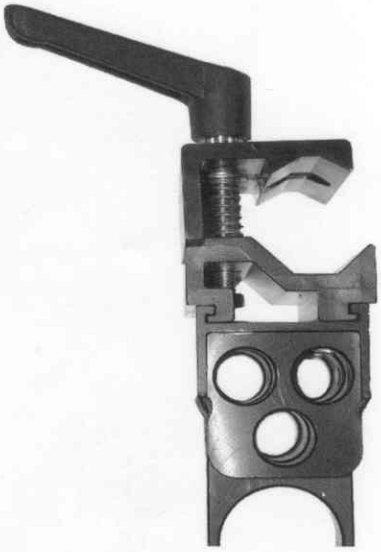
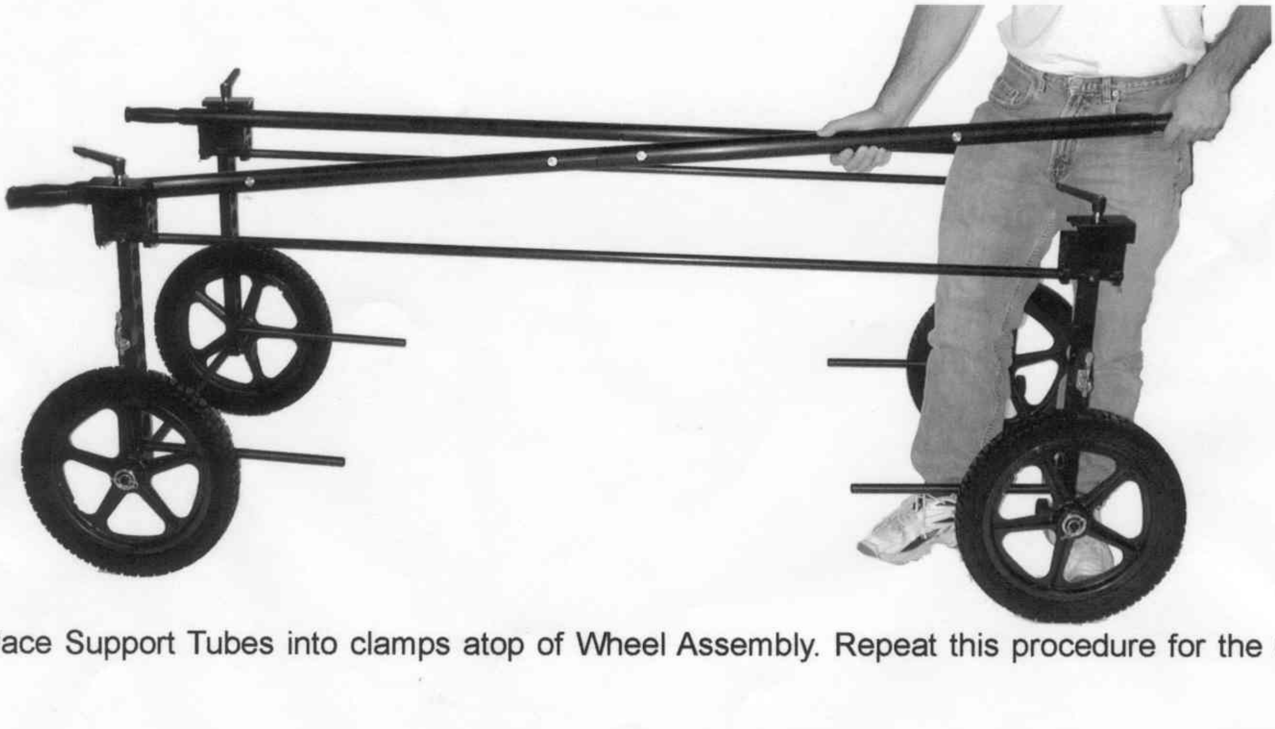


10. Assemble Support tubes (1-1/2") by inserting short 1-1/4" tube into 1-1/2" tubes until stainless steel snap buttons pop into holes in 1-1/2" tubing (Note: to adjust handle depress stainless steel button and slide handle outward until button snaps secure).



11. Prior to placing Support Tubes into Clamp Assembly atop Stanchion slide top of Clamp back (left). Once Support Tubes have been placed into the bottom of clamp place top of Clamp over Support Tube (right).





12. Place Support Tubes into clamps atop of Wheel Assembly. Repeat this procedure for the other side.

PRODUCT SPECIFICATIONS

Model: SR801 RT Fabric: N/A
Weight: 26 Pounds Components: Stainless Steel
Capacity: 500 .Ibs tandem axle
Frame: 6061- T6 Aluminum
Chassis: 6061- T6 Aluminum Height Width Length
Wheels: Fiberglass Reinforced Nylon Collapsed Bagged: 5" 25" 40"
Tires: 16" X 2" Micro-cellular Urethane Assembled /
Overall : 27" 31" 16"
Bearings: Sealed 440 Stainless Steel Transport : N/A N/A N/A
Finish: Black Anodized Stretcher: 27" 22" 72"

PARTS LIST

PART # QTY DESCRIPTION MATERIAL
NCO5017 4 STANCHION ASSEMBLY 6061- T6 ALUMINUM
6000110 8 BALL PLUNGER STAINLESS STEEL
6000117 4 WASHER STAINLESS STEEL
NCO5006 4 STANCHION KNOB POL YMER
NCOO048 4 SUPPORT TUBE 6061- T6 ALUMINUM
NCO5015 4 STRETCHER CLAMP ASSEMBLY 6061- T6 ALUMINUM
6000111 8 CAP SCREW STAINLESS STEEL
6000112 8 LOCK WASHER STAINLESS STEEL
NCO5034 2 TIE ROD ASSEMBLY 6061- T6 ALUMINUM
6000109 4 RUE PIN STAINLESS STEEL
NCO5033 2 SUPPORT TUBE ASSEMBLY 6061- T6 ALUMINUM
6000144 4 SNAP BUTTON STAINLESS STEEL
NCO5032 1 HANDLE SUB-ASSEMBLY 6061- T6 ALUMINUM/NYLON
6000144 2 SNAP BUTTON STAINLESS STEEL
NCO1072 2 AXLE 6061- T6 ALUMINUM
6000109 4 RUE PIN STAINLESS STEEL
NCO5025 4 WHEEL ASSEMBLY NYLON
6000133 8 BEARING STAINLESS STEEL
6000134 4 TIRE URETHANE

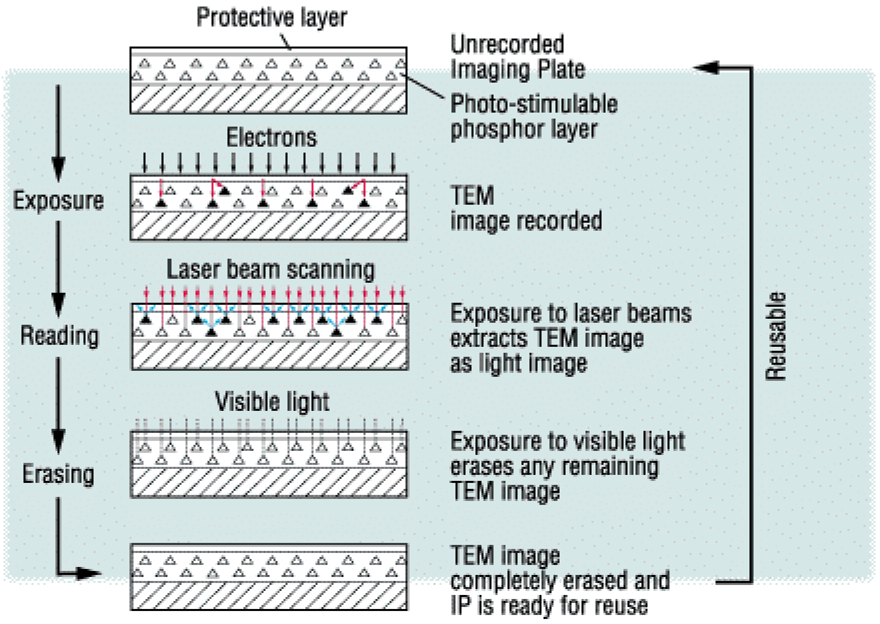
CANVAS COMPONENTS

2044810 1 BAG-CARRY 1000 DENIER NYLON
2021811 2 BAG-AXLE 18 .oz SHELTER RITE
2046811 1 BAG- TIE ROD 18 .oz SHELTER RITE
2047811 1 BAG-SUPPORT TUBE 18 .oz SHELTER RITE
PATENTS 6,142,491 6,164,671, 6,270,092 7

ACR2000 OVERVIEW

The ACR200 line is a series of desktop CR systems made by Lumisys. The "A" in ACR stands for affordable. These Affordable Computed Radiography desktop systems are designed for the small to moderate sized doctor's office or clinic. They use Image Plates instead of x-ray film and screens in a cassette. The idea for a photo stimulated x-ray plate employing storage phosphor sensor technology was patented by Kodak in 1976. In 1982 Fuji patented the phosphor that is used. Storage phosphor radiography systems employ an imaging screen containing storage phosphor crystals to capture a latent radiation image. The phosphor grains are coated on a flexible substrate and store the incident radiation energy in the form of trapped electrons - thus the name storage phosphor. Storage phosphor/CR imaging was introduced in the mid-1980's. The first commercial product was developed by the Fuji Corporation of Japan. Subsequently, the basic Fuji system was marketed and sold through several other radiology equipment manufacturers including Toshiba, and Philips.

Storage phosphor systems have the advantage of a wide dynamic range of about 1 :10,000 vs. 1:100 for film. With storage phosphor, the images are either viewed on film after printing with a laser printer or on a high resolution monitor. The optical density or tone scale of a radiograph from an IP can be controlled by the computer. Therefore, overexposure does not result in a dark image and underexposure does not produce a light image.


Protective layer
Unrecorded Imaging Plate
Photo-stimulable phosphor layer
Electrons
Exposure
TEM image recorded
Laser beam scanning
Reading
Exposure to laser beams extracts TEM image as light image
Visible light
Erasing
Exposure to visible light erases any remaining TEM image
TEM image completely erased and IP is ready for reuse
Reusable

Imaging Plates have a flexible polyester base coated with highly dispersed barium fluorohalide phosphor crystals ($BaF(Br,I):Eu^{2+}$). When an x-ray strikes an IP, the energy is transferred to the phosphor crystals, and stored as trapped electrons. In short, the electrons become trapped to form ' F-centres' in the BaF(Br,I) matrix and Eu^{2+} ions trap holes. These F-centres have an absorption band at about 600nm. So scanning the exposed IP with the Ne-He (633nm) laser releases the trapped electrons to the conduction band. The trapped electrons recombine with the holes trapped by Eu^{2+}, and photons at about 400 nm are released. This process is known as photo-stimulated luminescence. The blue light emitted is collected to produce the digitised image.

An ACR2000 uses 2 Photo Multiplier Tubes to capture the released PSL light given off when the Image plate is scanned by the laser beam. This blue light is of a very low intensity and requires a highly sensitive collection system. The PMTS are 3 inches in diameter and have 8 active dynodes each versus the ¾ inch diameter and 4 dynodes of the film digitizers. The collection chamber is also much larger and has slots cut in both the front and back sides. The laser beam passes through the front slot of the chamber and hits the image plate after passing through the back slot as the plate is being fed down the outside of the chamber. The PSL given off by the plate is reflected into the chamber, which is coated similarly to the film digitizer, captured by the PMTS. The PMTS are covered by blue filters to block the reflected red laser light from reaching the tubes. There is also a blue plastic filter fitted into the bottom half of the chamber to absorb scattered red light and improve the collection efficiency of the chamber and tubes.

The laser for an ACR is much more powerful than the ones used in the digitizers. It is a 35 mW solid state diode laser rather than a 2mW gas as used in the digitizer. However about half the output is taken up by the optical fiber and ref amp sensor mirror giving about 18 mW of useful power at the image plate. The ref amp sensor pass through mirror uses about 10% of the power with the optical fiber absorbing the rest. The beam itself is much larger in diameter than the digitizer's. It is 5mm in size, elliptically shaped, and astigmatic due to the source having two points of origin. There is also a fair amount of back scatter caused by the gold plated housing of the diode. This is all cleaned up by running the beam through an optical fiber of 4 microns in diameter and then refocusing it back to 87 microns with a lens assembly before passing the beam to the same scanning galvanometer as used in the digitizer.

The ACR implements an automatic gain control similar in feature but entirely different in execution. Rather than collect red laser light during a scan through air. The ACR uses a blue LED placed in the collection chamber as a known output light source. By running DDT option 20 and pressing B to turn the blue LED on we can set the parameters for AGC sensitivity of a count of 1071. This is done after first setting the high voltage sensitivity of the PMTs using an image plate with an 8 mas exposure and adjusting R140 on the DACQ board to give a count of 600 when scanning the plate.

The ISFILM signal is handled differently also. Instead of measuring an absorption of 0.14 OD by a film, a photodiode is placed next to the blue LED in the chamber to pick up the reflected red laser light given off when an IP is passed by the collection slot. The high intensity reflection serves to make ISFILM true.

Computed Radiography Acceptance Testing & Quality Control

Jonathan E. Tucker, Ph.D., DABR
Diagnostic Radiological Physicist
Department of Radiology, Brooke Army Medical Center

Brooke Army Medical Center (BAMC)

- 460 bed Level I trauma center
- GME for 550 medical students
- Army's only certified Level I trauma center
- Great Plains Regional Medical Command
- Institute of Surgical Research

BAMC Radiology

Totally digital department (almost)

- DSA/CT/Ultrasound/MRI
- Computed Radiography (CR)
- Direct Radiography (DR)
- Digital Mammography
  - diagnostic (Fischer prototype)
  - stereotactic breast biopsy
- PACS/Teleradiology

PICKER
PQ 6000

Computed Radiography (CR)

- Replaces all film except for mammography.
- Uses photostimulable storage phosphors.
- System consists of image plates, cassettes & plate reader.
- Direct digital image production for PACS.
- Provides 70% of radiological images.
- BAMC
  - 6 CRs for 20 x-ray units at 6 locations
  - Directly interfaced to PACS

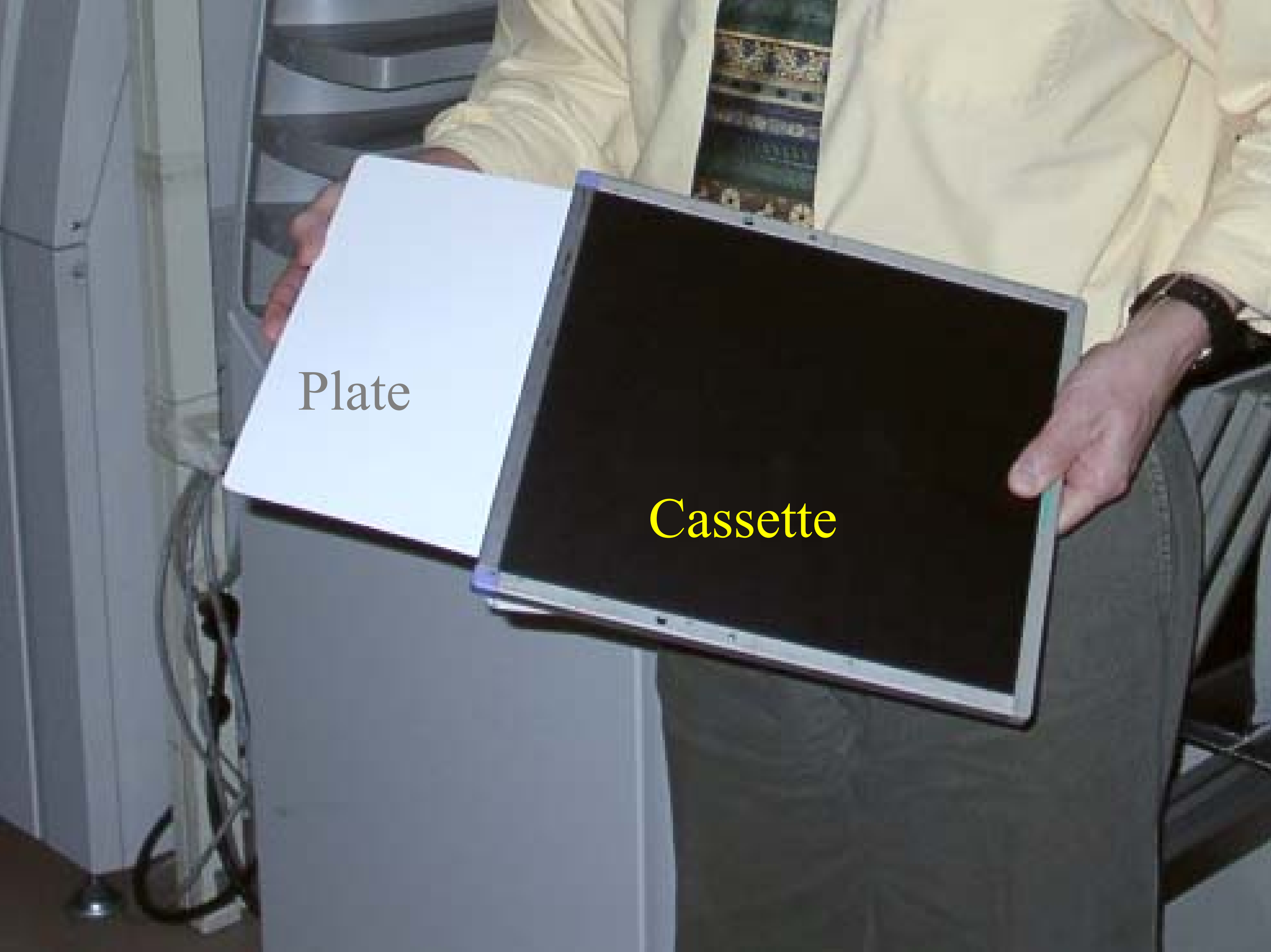
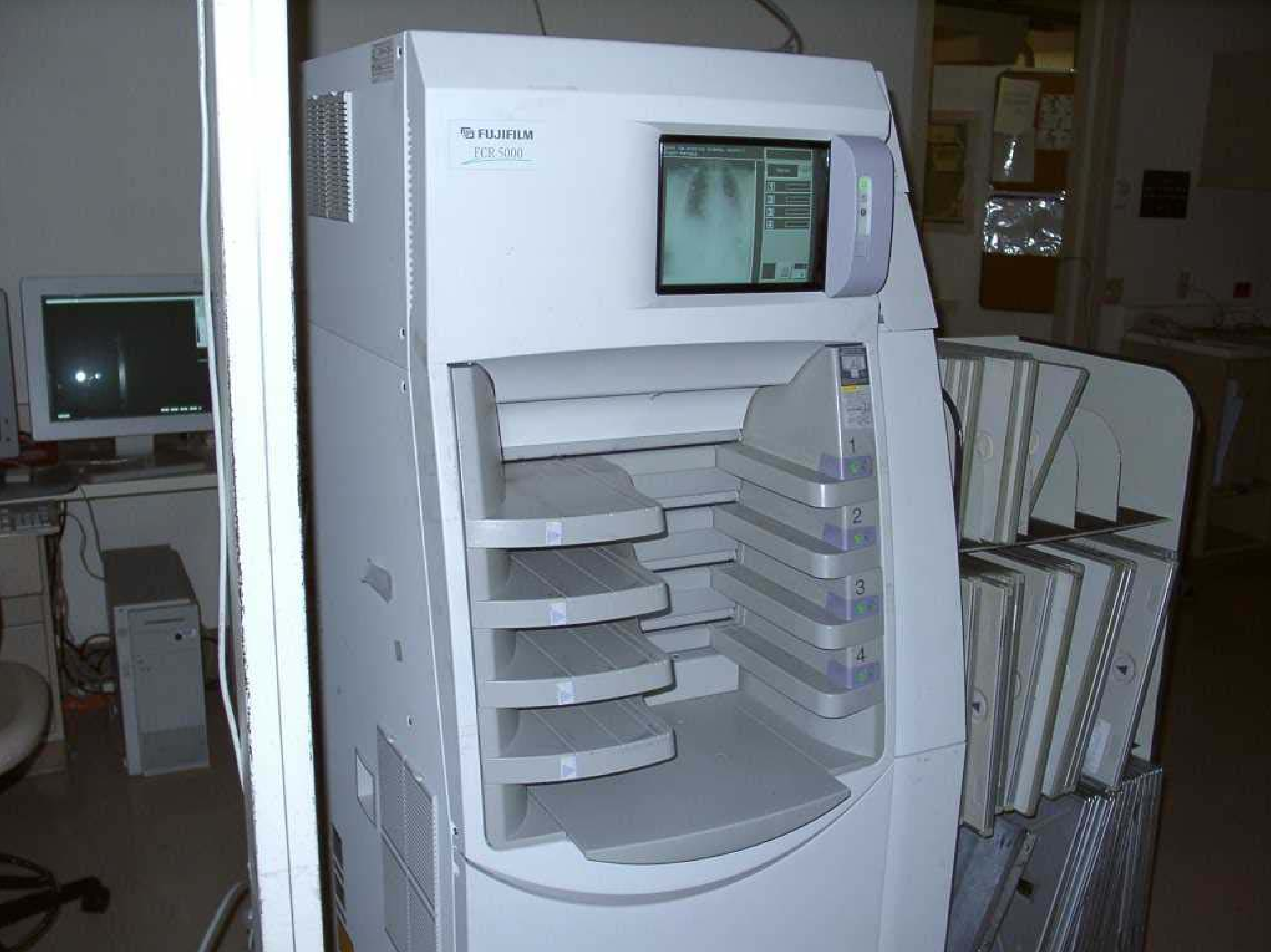
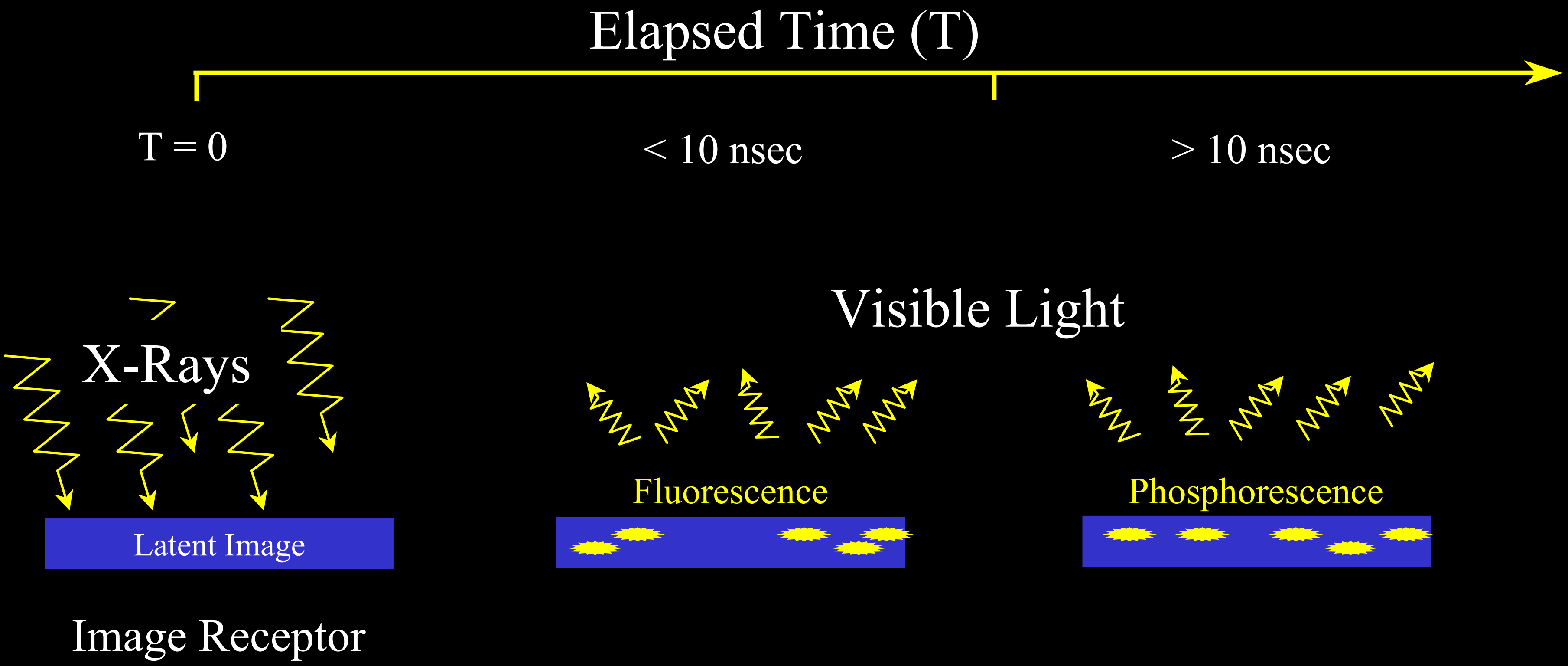


Plate
Cassette


FUJIFILM
FCR 5000
1
2
3
4

Photostimulable Storage Phosphor (PSP) Systems

Luminescence



Elapsed Time (T)

T = 0

< 10 nsec

> 10 nsec

X-Rays

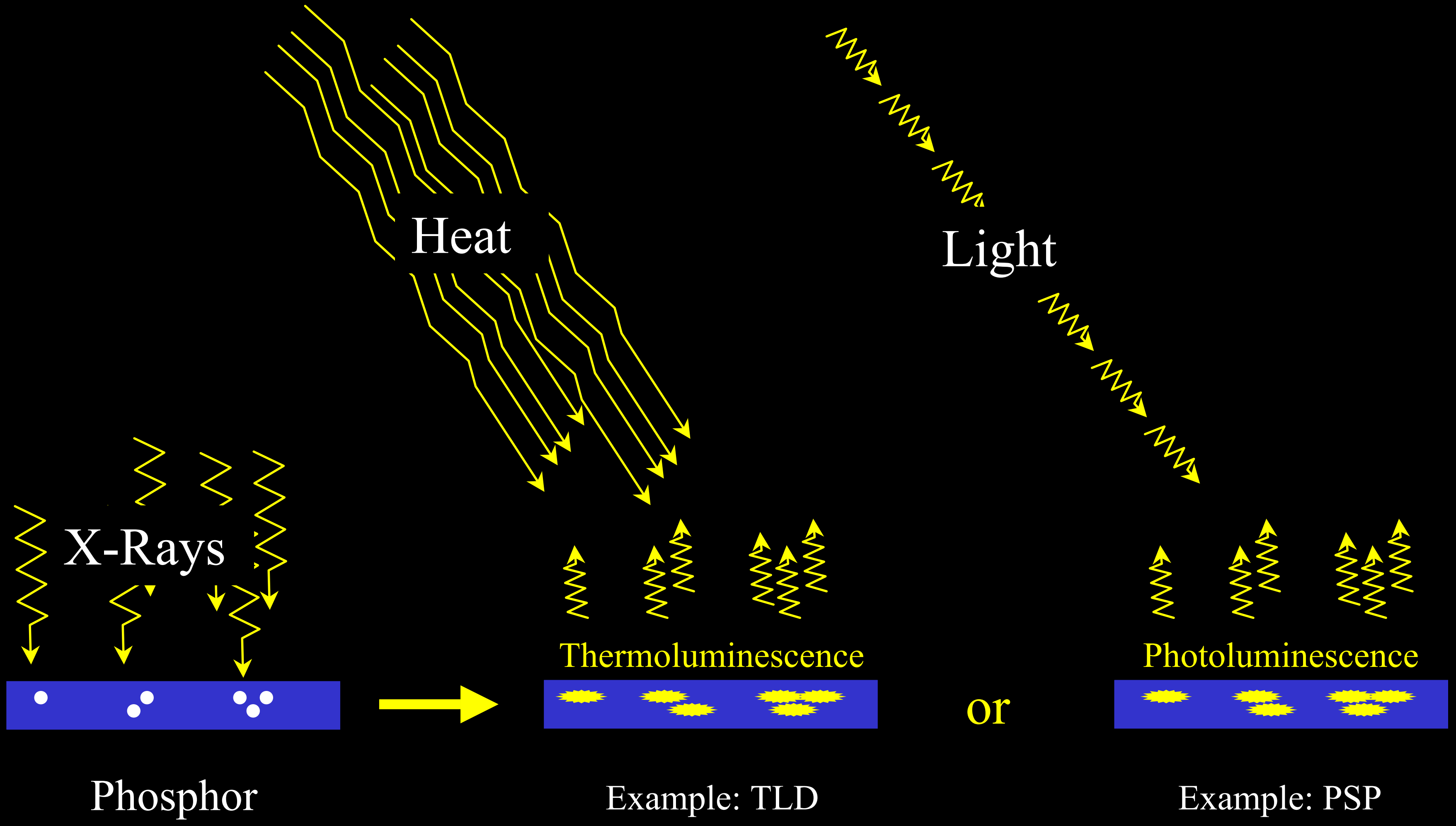
Latent Image

Image Receptor

Visible Light

Fluorescence

Phosphorescence


Heat
Light
X-Rays
Thermoluminescence
Photoluminescence
or
Phosphor
Example: TLD
Example: PSP

Photostimulable Storage Phosphors (PSPs)

- Hold absorbed x-ray energy in a quasi-stable state within the crystal lattice.

- When exposed later to another energy source, the phosphor may re-emit the absorbed energy.

- PSPs can be stimulated to release their energy by exposure to intense visible light.

Mechanism

- PSPs used in CR: europium-doped barium fluorohalides.
  - BaFI:Eu^{+2}, BaFCl:Eu^{+2}, and BaFBr:Eu^{+2}
  - Eu^{2+} is an activator (creates activator sites in the crystal).

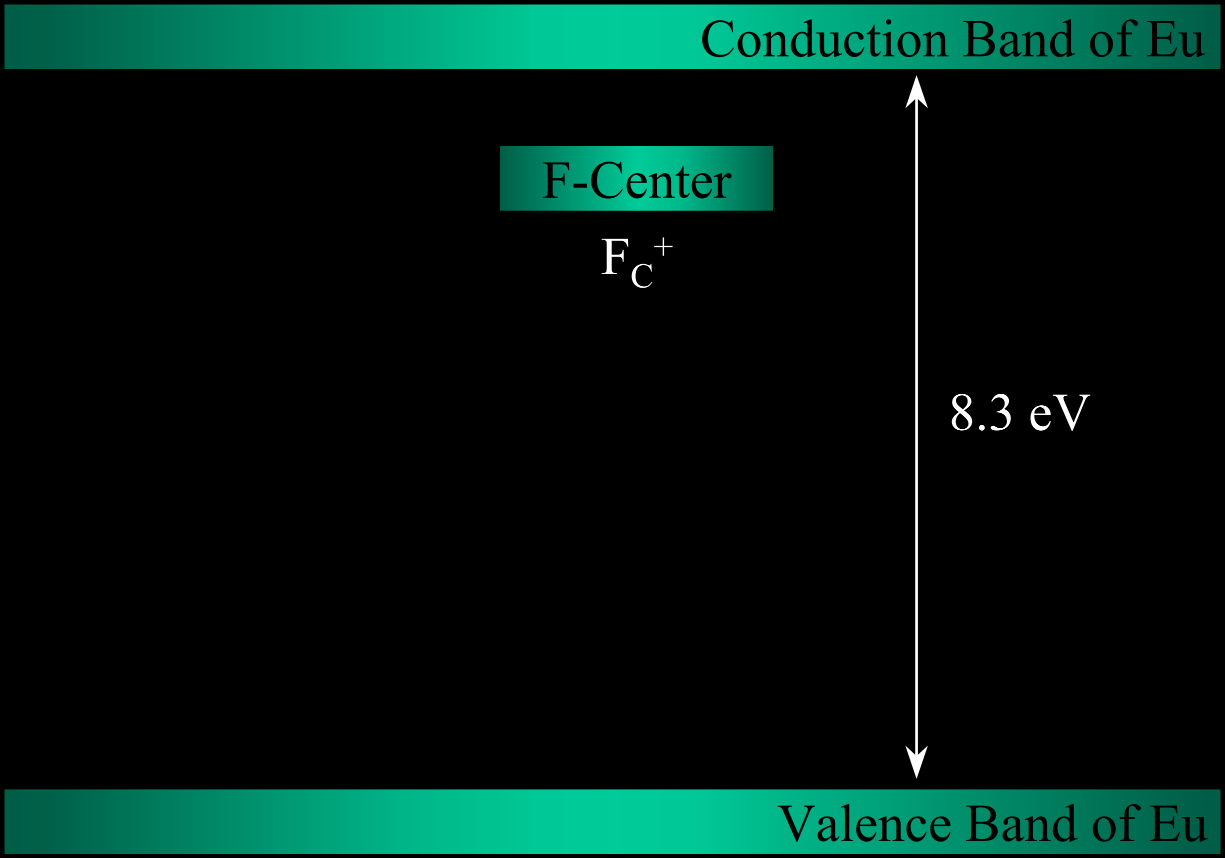
- X-rays absorbed by the PSP oxidize Eu^{2+} to Eu^{3+}.
  - Some excited electrons recombine immediately with the Eu^{3+}.
  - Some excited electrons are captured at F-centers (PSP crystal defects, NOT fluorine atom locations).

Mechanism

- Over time, all trapped electrons migrate back to the electron holes due to thermal processes.

- In Computed Radiography (CR), a scanning HeNe laser is used to release the latent image from the storage phosphor imaging plate (IP).

- The emitted light is proportional in intensity to the x-ray energy absorbed locally in the phosphor.



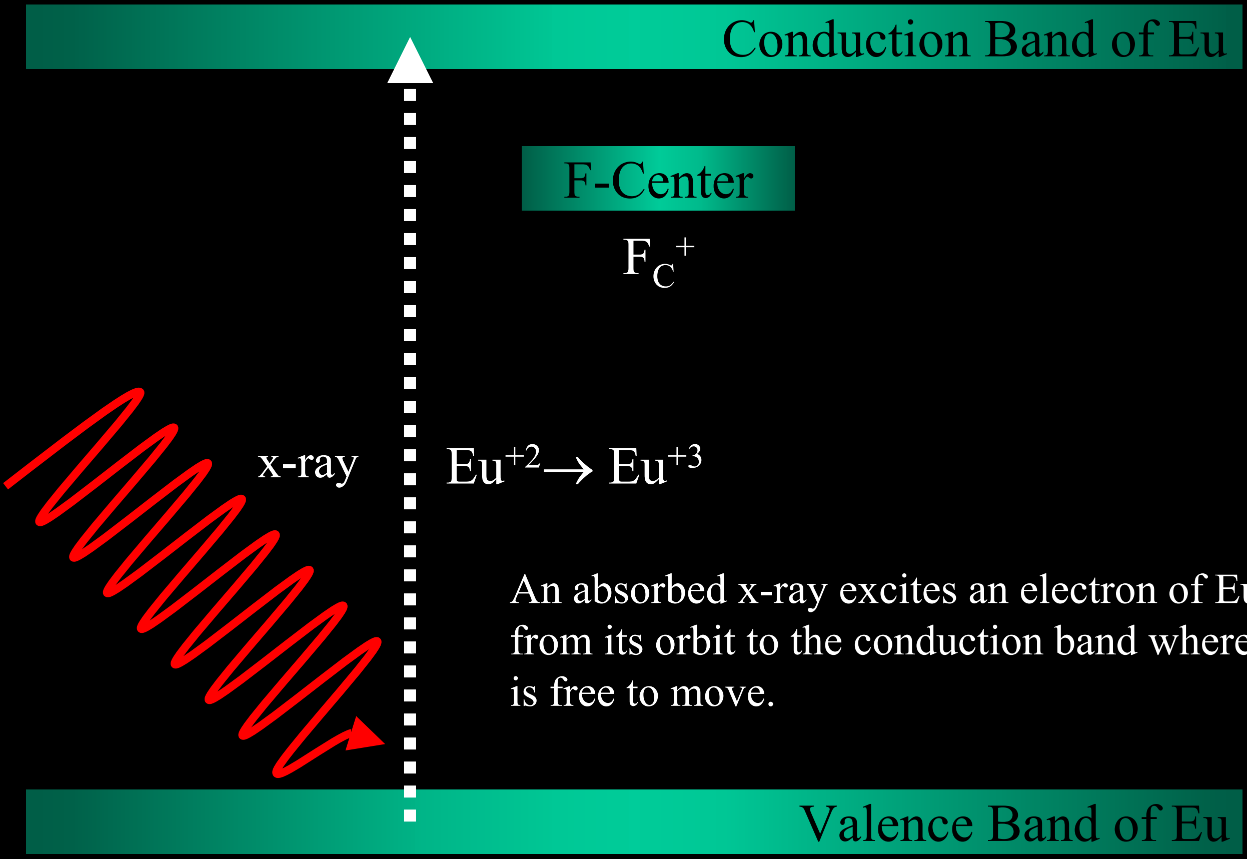
Conduction Band of Eu

F-Center

F_C^+

8.3 eV

Valence Band of Eu



Conduction Band of Eu

F-Center

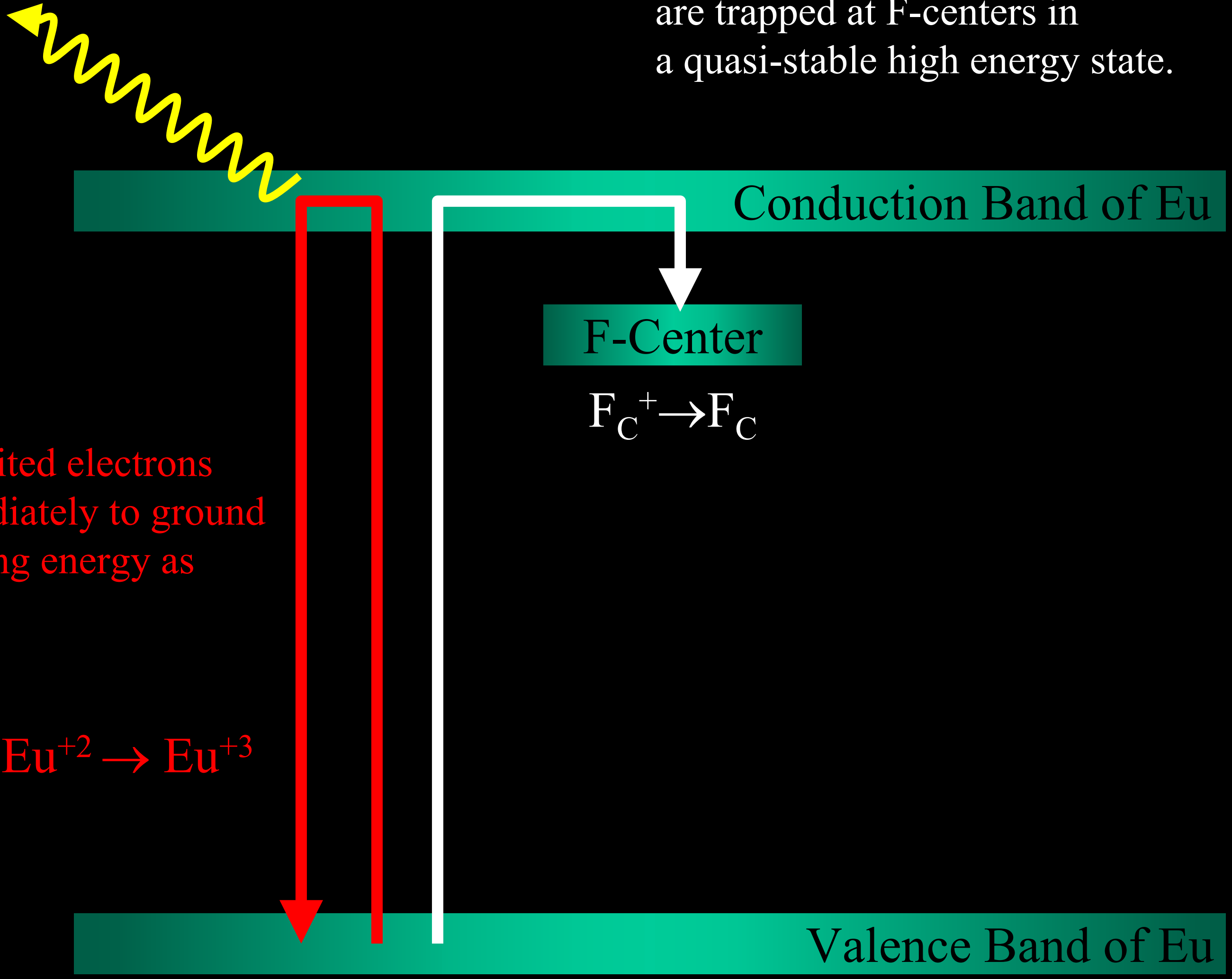
F_C^+

x-ray

$Eu^{+2} \rightarrow Eu^{+3}$

An absorbed x-ray excites an electron of Eu^{+2} from its orbit to the conduction band where it is free to move.

Valence Band of Eu



prompt emission
of visible light
(300-500 nm)

~50% of excited electrons
are trapped at F-centers in
a quasi-stable high energy state.

Conduction Band of Eu

F-Center

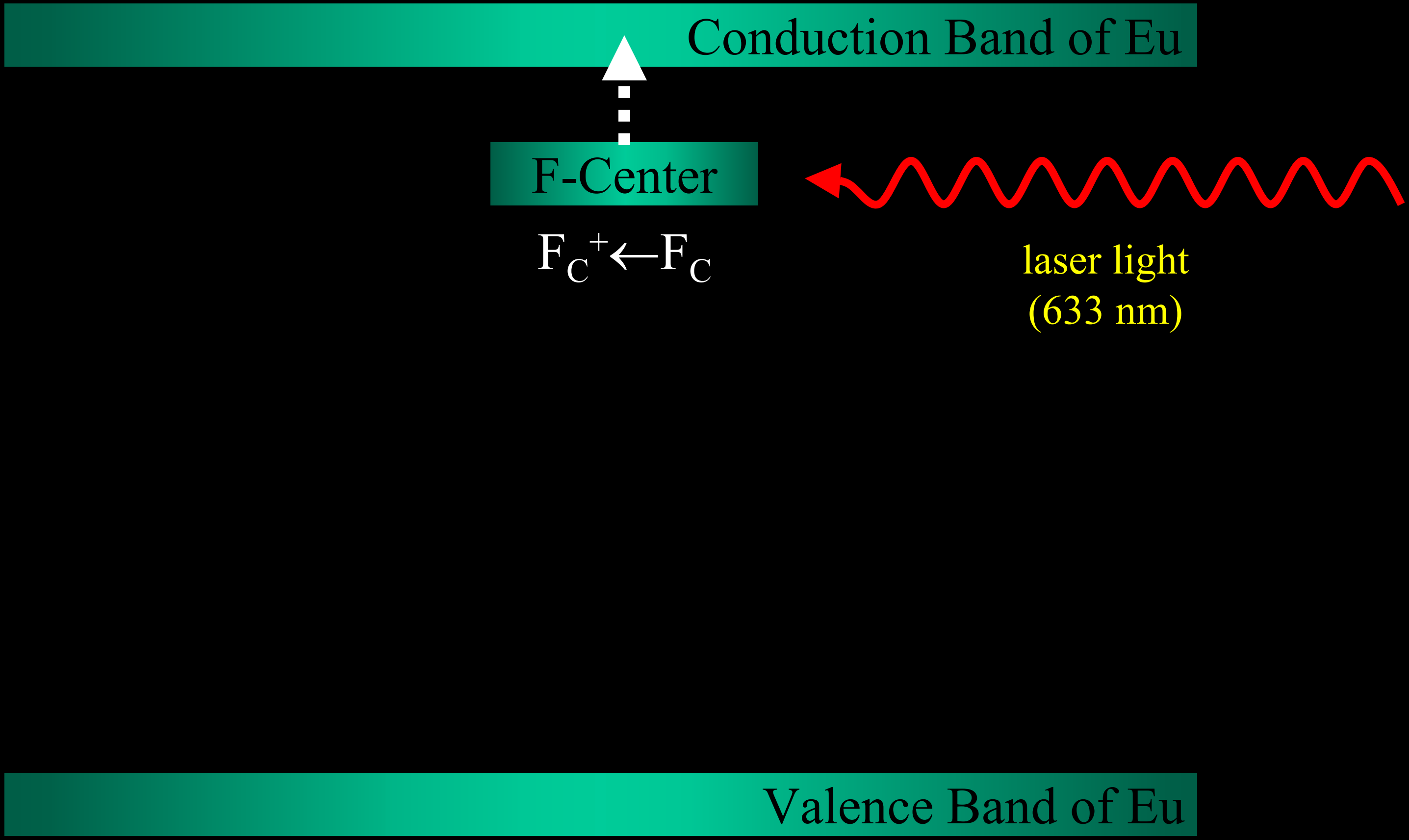
$F_C^+ \rightarrow F_C$

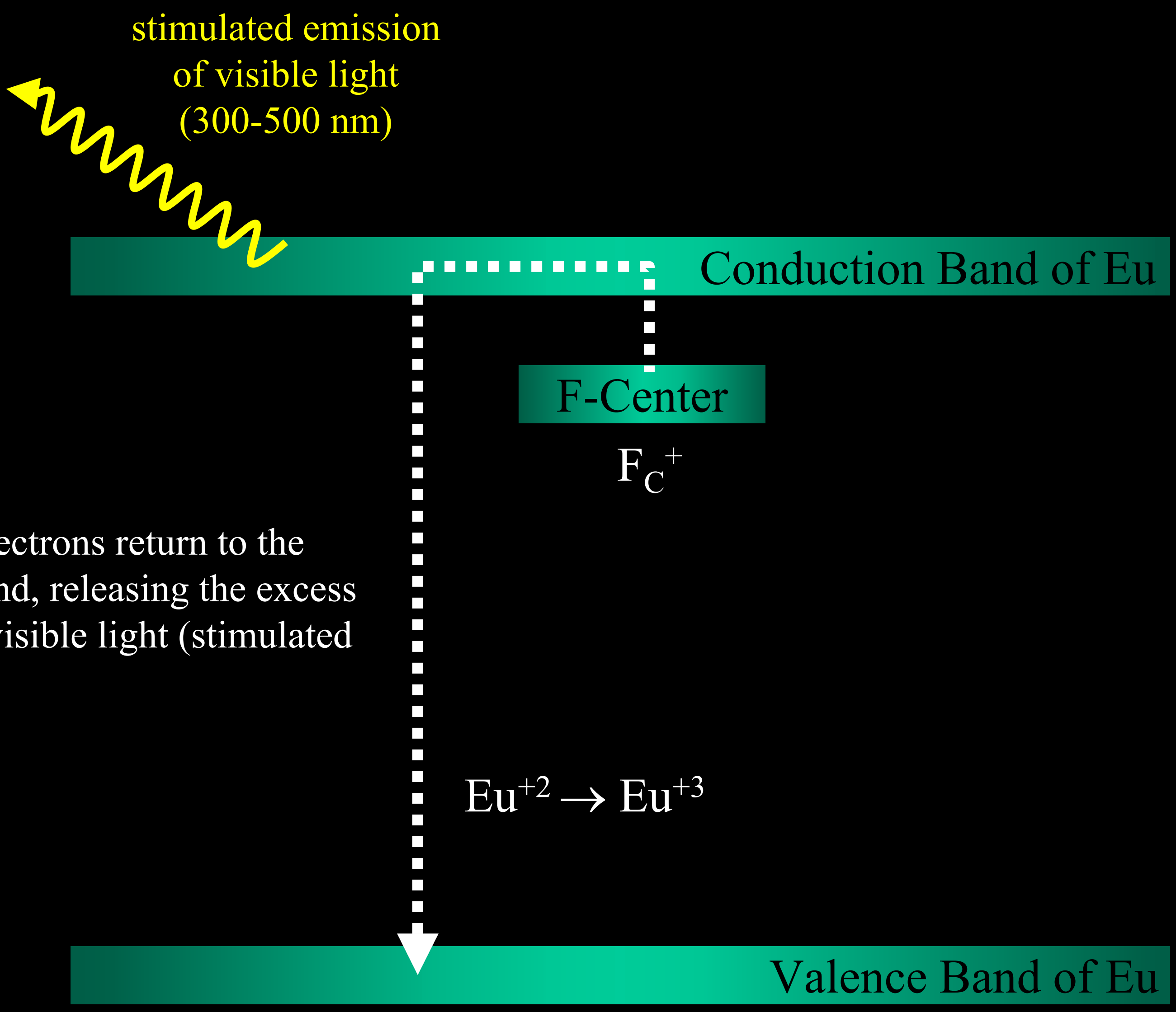
~50% of excited electrons return immediately to ground state, releasing energy as light.

$Eu^{+2} \rightarrow Eu^{+3}$

Valence Band of Eu

To determine the spatial distribution of trapped energy, the plate is exposed line by line to a helium neon (HeNe) laser to raise the energy level of each trapped electron to the conduction band.


Conduction Band of Eu
F-Center
$F_C^+ \leftarrow F_C$
laser light
(633 nm)
Valence Band of Eu



stimulated emission
of visible light
(300-500 nm)

Conduction Band of Eu

F-Center

F_C^+

Trapped electrons return to the valence band, releasing the excess energy as visible light (stimulated emission).

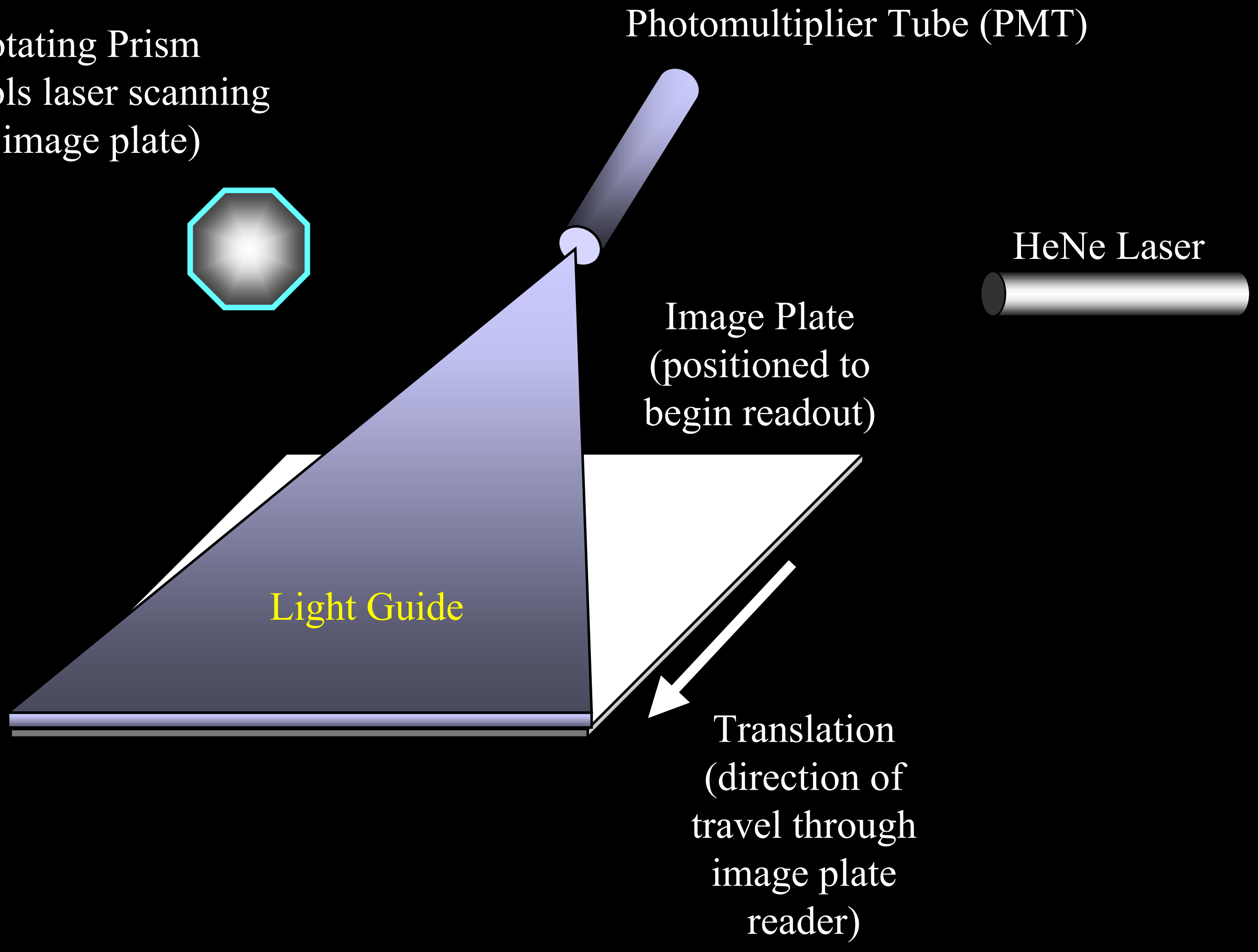
$Eu^{+2} \rightarrow Eu^{+3}$

Valence Band of Eu

Equipment

- PSPs are formed into imaging plates (IPs).
  - IPs are similar to intensifying screens.
  - IPs are placed inside a cassette and exposed to x-rays.
- The exposed cassette is placed in a read-out unit. The IP is:
  - removed from the cassette
  - scanned pixel by pixel by a helium neon (HeNe) laser
    - HeNe laser wavelength: 633 nm
    - Light emitted by the de-exciting electrons: 300 to 500 nm
    - Detection system filters prevent detection of scattered laser light.
- The electronic detector records the amount of light released at each pixel of the IP. The analog signal from each pixel is digitized and assigned a gray scale value.

Computed Radiography Concepts



Rotating Prism
(controls laser scanning
of image plate)

Photomultiplier Tube (PMT)

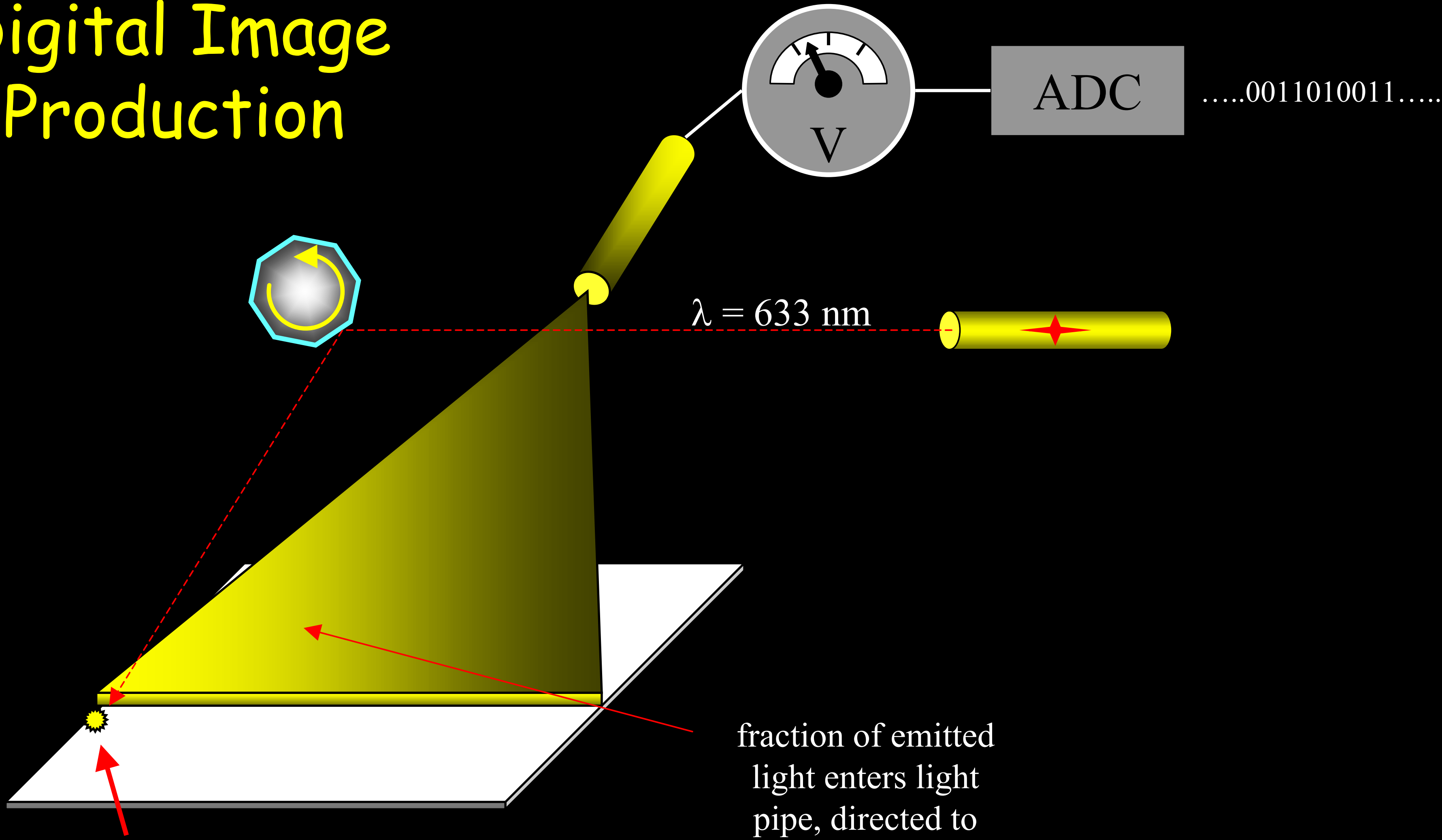
HeNe Laser

Image Plate
(positioned to
begin readout)

Light Guide

Translation
(direction of
travel through
image plate
reader)

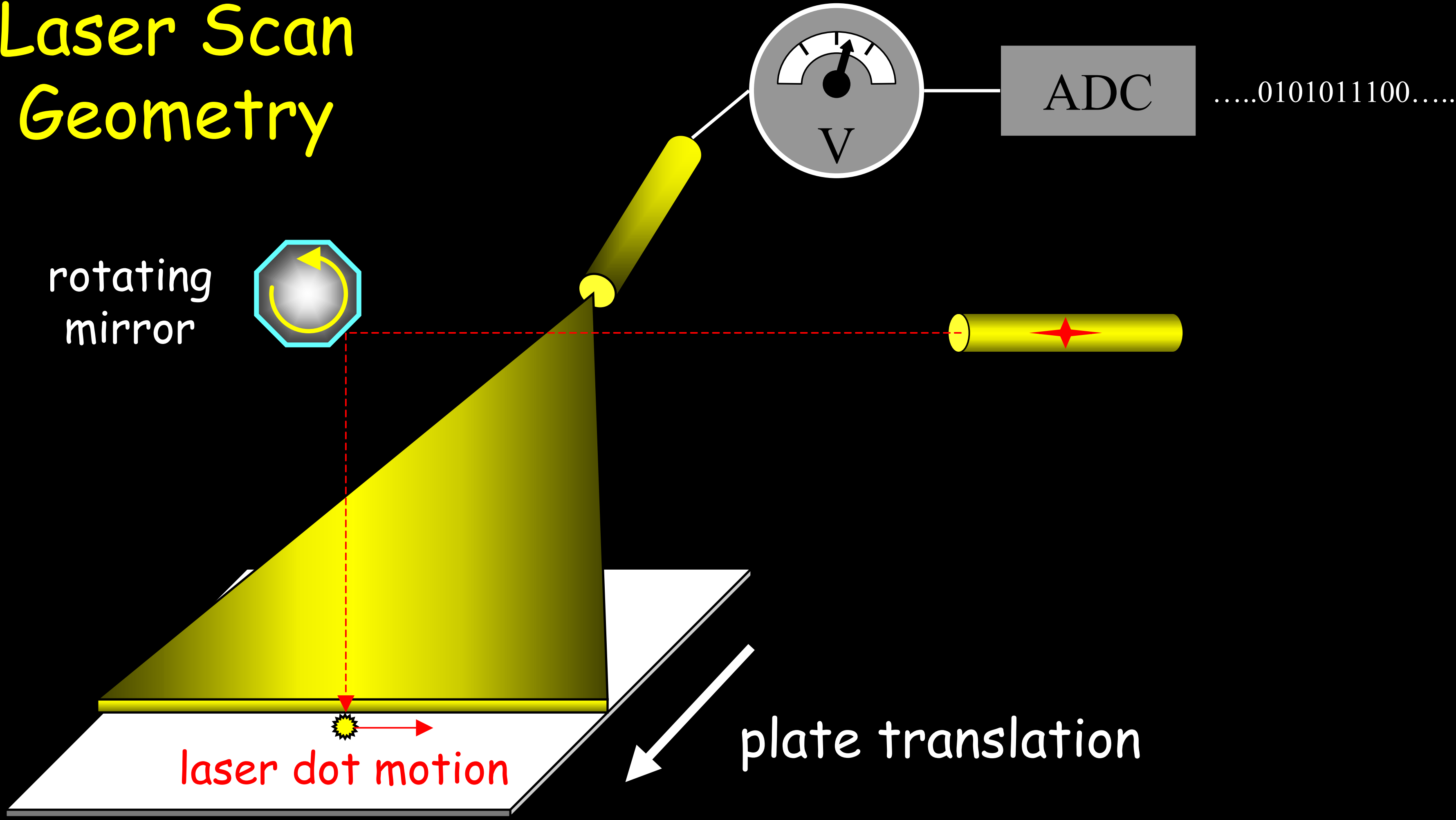
Digital Image Production

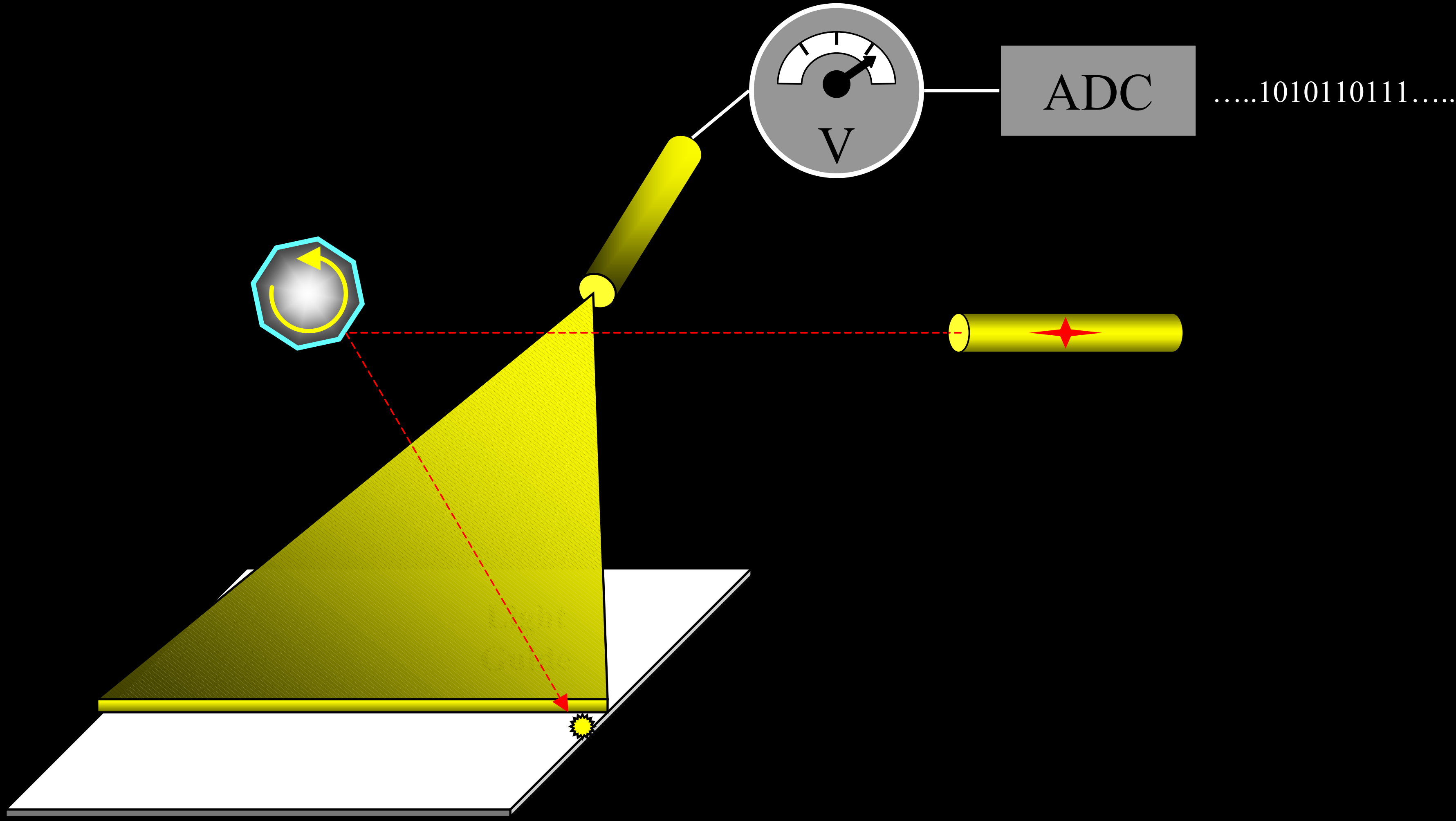

V
ADC
…..0011010011…..
λ = 633 nm

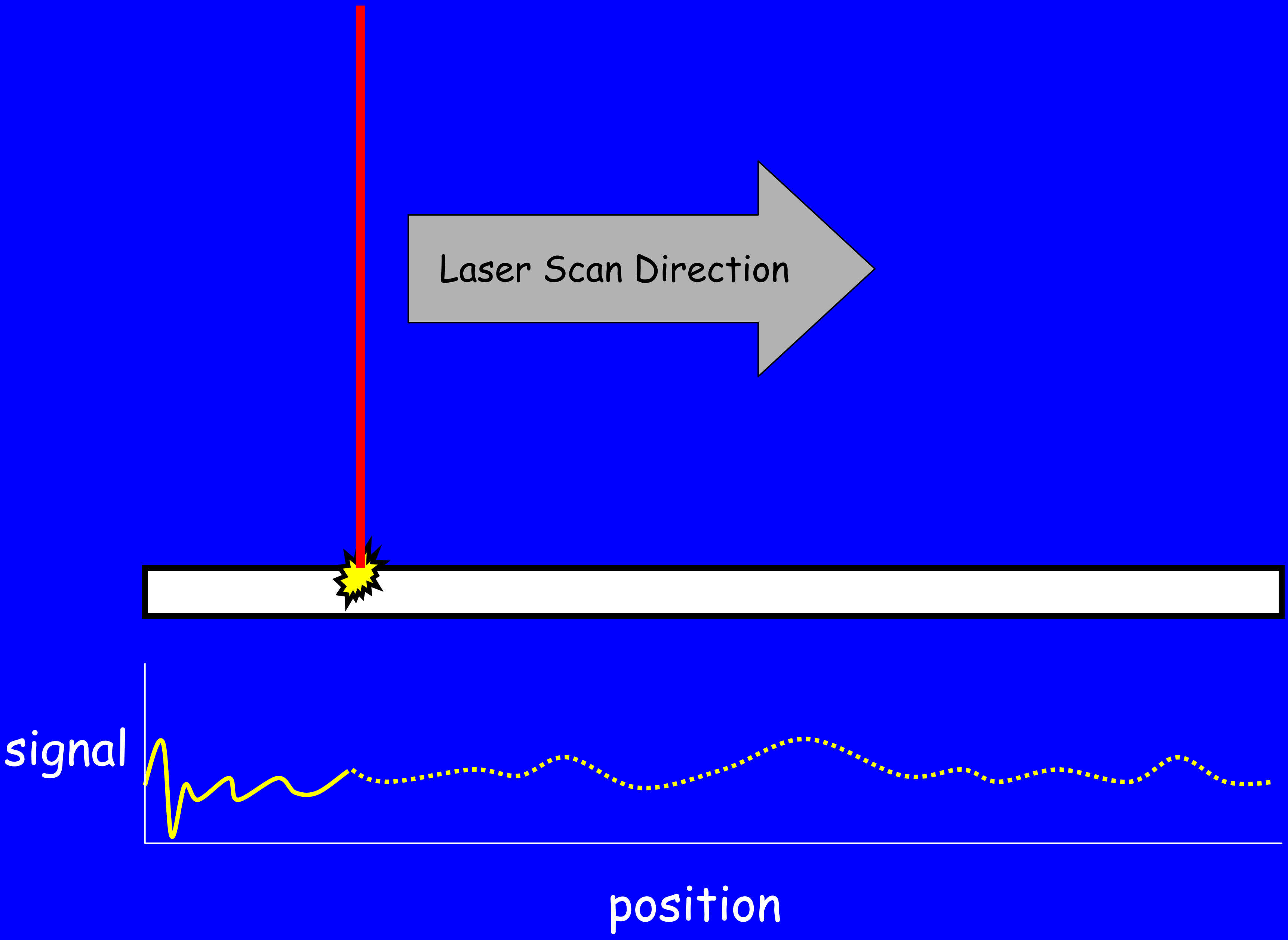
fraction of emitted
light enters light
pipe, directed to
PMT

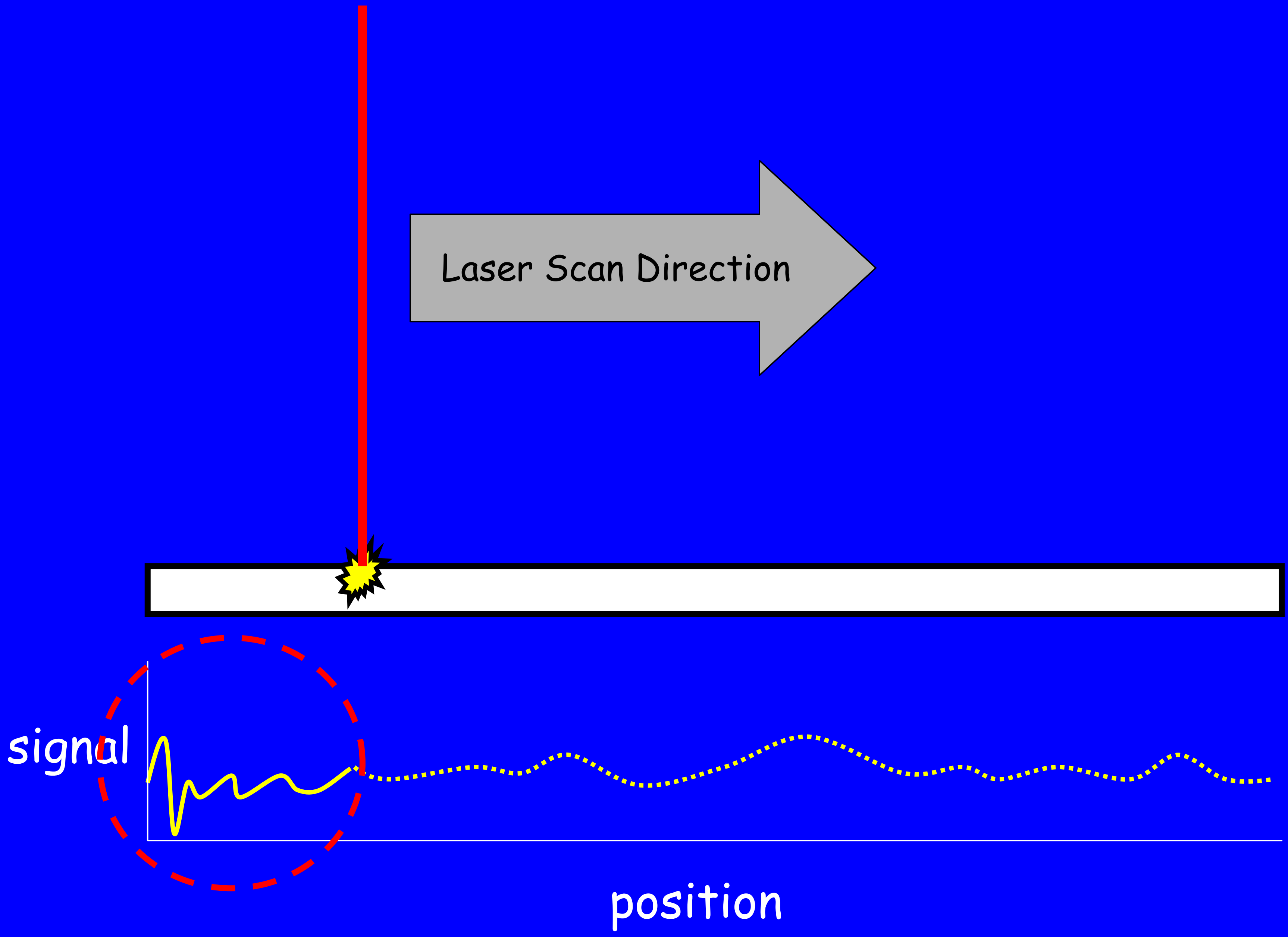
light emission
from image plate
(λ = 300-500 nm)

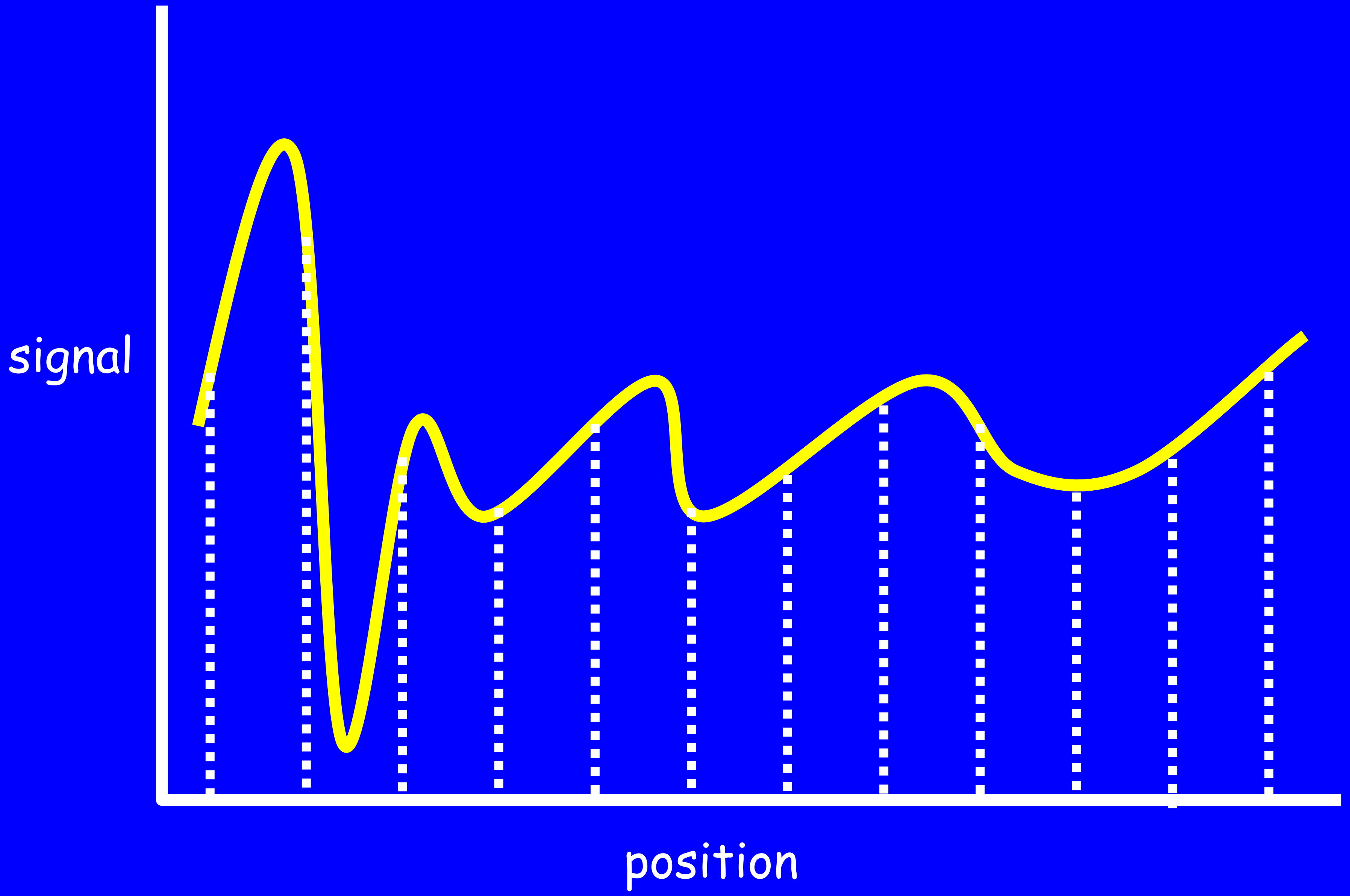
Laser Scan Geometry

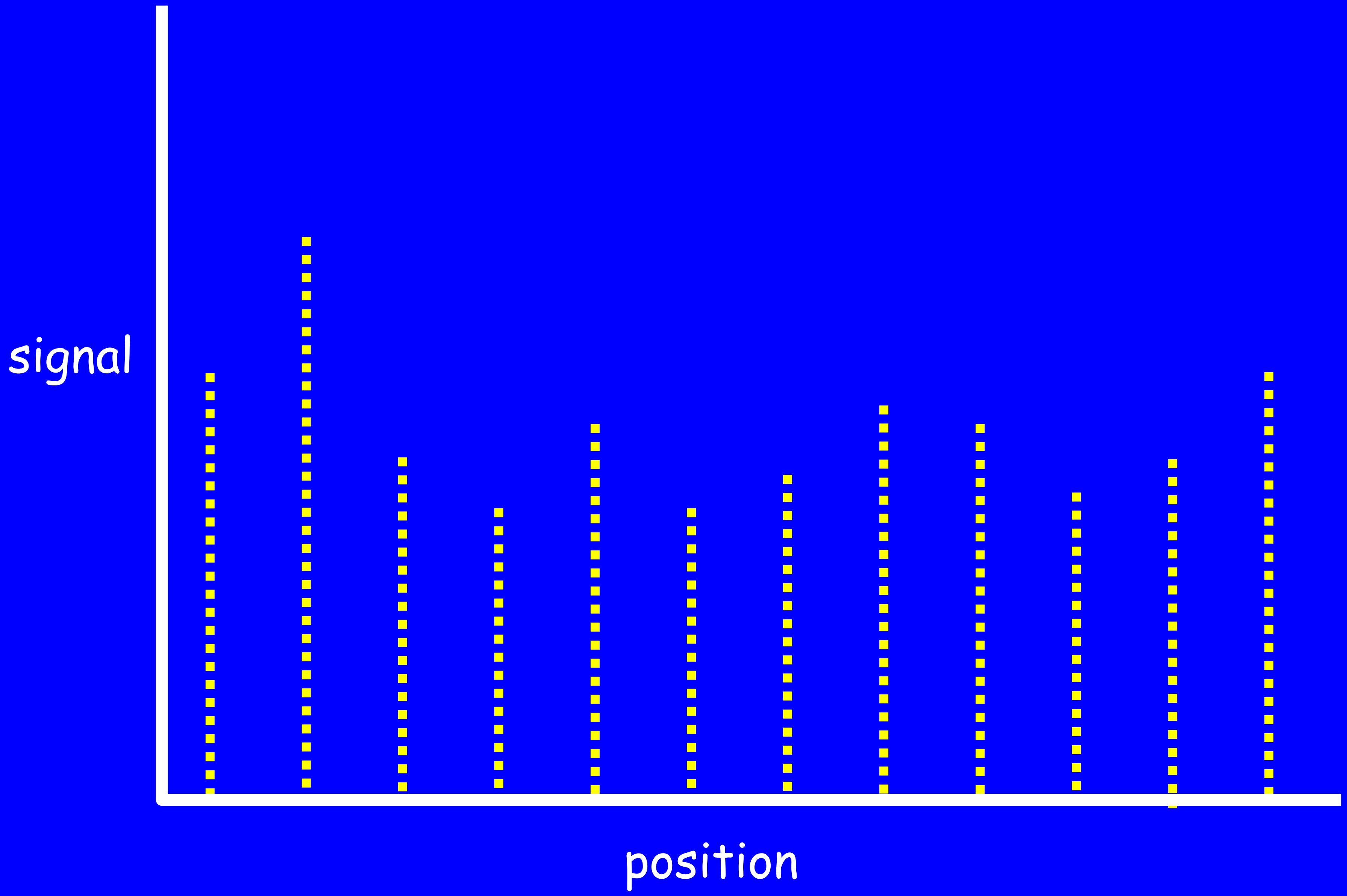

V
ADC
.....0101011100.....
rotating mirror
laser dot motion
plate translation

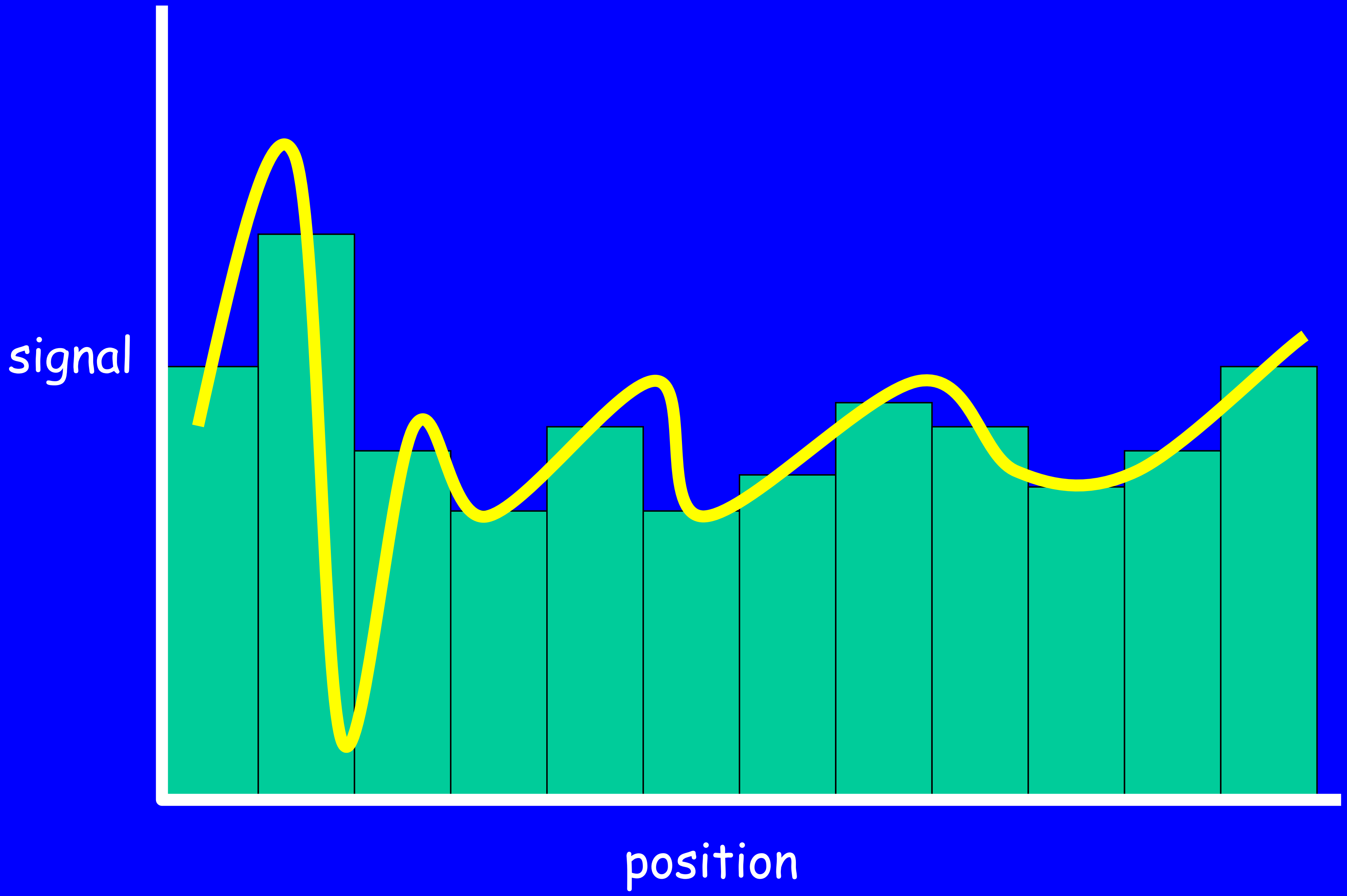

V
ADC
.....1010110111.....
Light
Guide

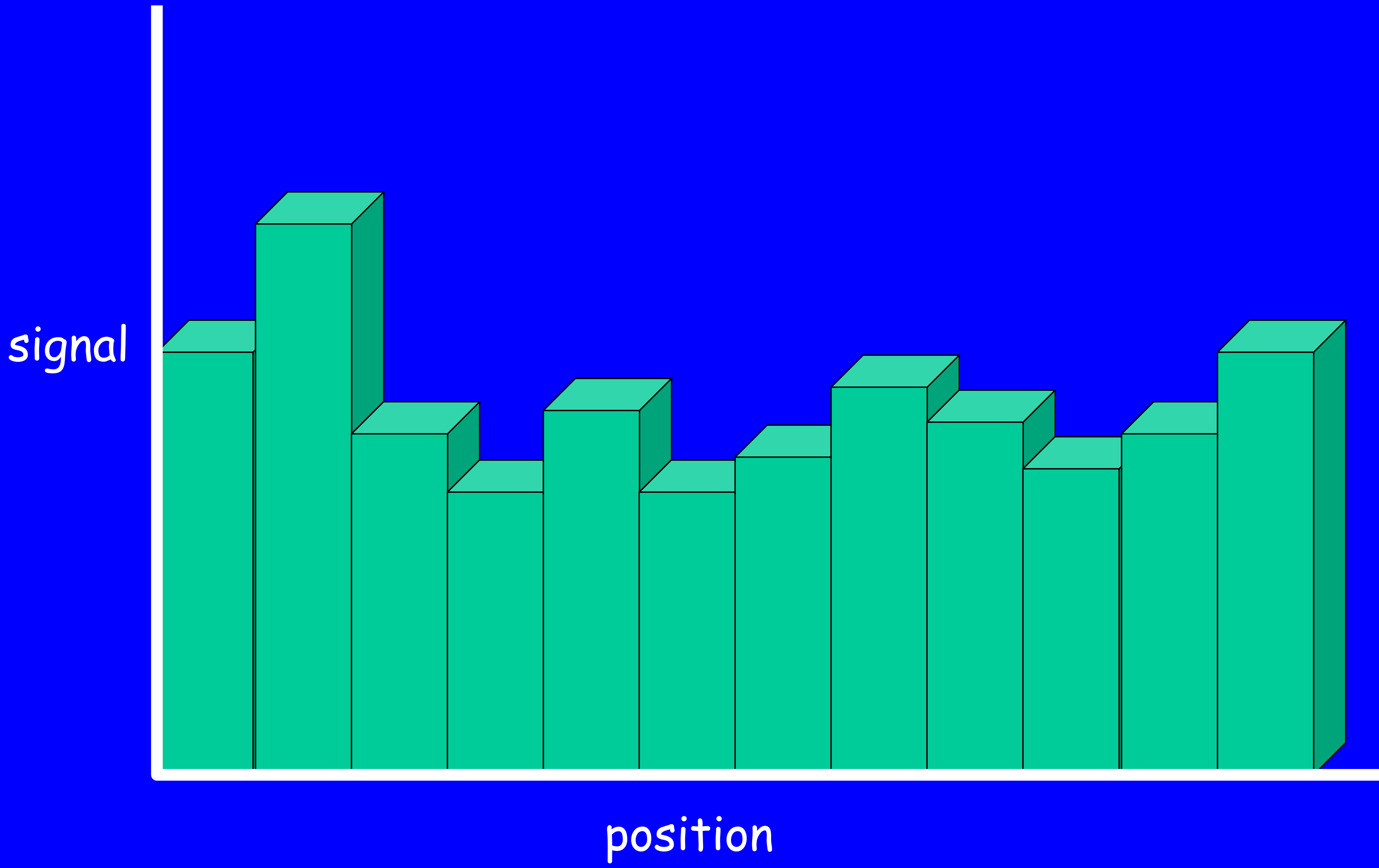

Laser Scan Direction
signal
position

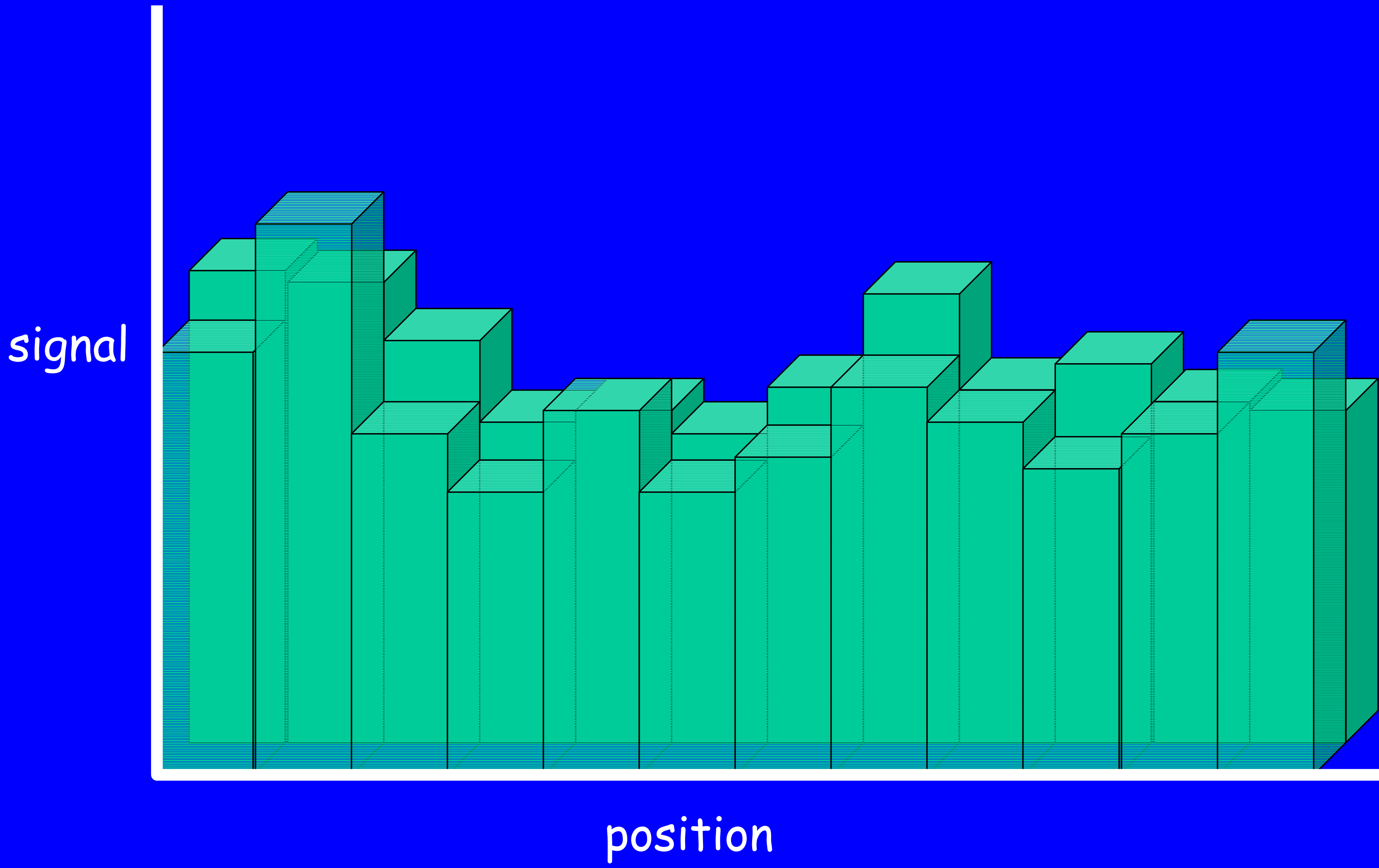

Laser Scan Direction
signal
position


signal
position


signal
position


signal
position


signal
position


signal
position

Standards for Computed Radiography QC

- AAPM Diagnostic Imaging Committee, Task Group 10 - Computed Radiography
  - expected publication 2002
  - input from Fuji, Kodak, and Agfa
- Samei, Ehsan et al., Performance evaluation of computed radiography systems. Medical Physics 28(3) 361-71, March 2001.
  - field test of TG 10 methods
  - establishes reasonable performance standards

Computed Radiography QC

- Phosphor Plate Dark Noise
- System Linearity, Auto-Ranging and Exposure Response
- Receptor Reproducibility, Density Uniformity & Artifact Analysis
- Phosphor Plate/Cassette Throughput
- Laser Beam Function
- Spatial Resolution
- Wire Mesh Test - Resolution Uniformity Across Receptor
- Low Contrast Sensitivity/Detectability
- Distance Accuracy Measurements and Aspect Ratio Test
- Accuracy/Thoroughness of Erasure Cycle

Phosphor Plate Dark Noise

- Erase imaging plates (IPs) to remove all residual image signal from background radiation and other sources.
- Adjust image plate reader gain to maximum and scan erased image plates.
- Workstation display of images should be clear, uniform and artifact-free.

System Linearity, Auto-Ranging and Exposure Response

- Expose three IPs of each size to 0.1, 1.0, and 10 mR.
  - uniform exposures (~180 cm SID)
  - 80 kVp and added filtration as specified by manufacturer

- Process each IP at 10 minutes after exposure using readout algorithm specified by the manufacturer for exposure index calibration. Obtain the exposure index (EI) displayed on
  - PACS image display workstation
  - image plate reader QC workstation
  - film (if image is sent to printer)

- Calculate IP exposure from the IP exposure index and compare to the measured exposure.

Fuji Exposure Index (S-number)

$$S = \frac{200}{\text{Exposure in mR}}.$$

$$\text{Therefore Exposure (mR)} = \frac{200}{S}$$

S	mR
20	10
200	1
2000	0.1

Kodak Exposure Index (EI)

$$\mathrm{EI} = 1000 \times \log_{10}\left(\text{Exposure in mR}\right) + 2000.$$

$$\text{Therefore Exposure (mR)} = 10^{\left(\frac{\mathrm{EI}-2000}{1000}\right)}$$

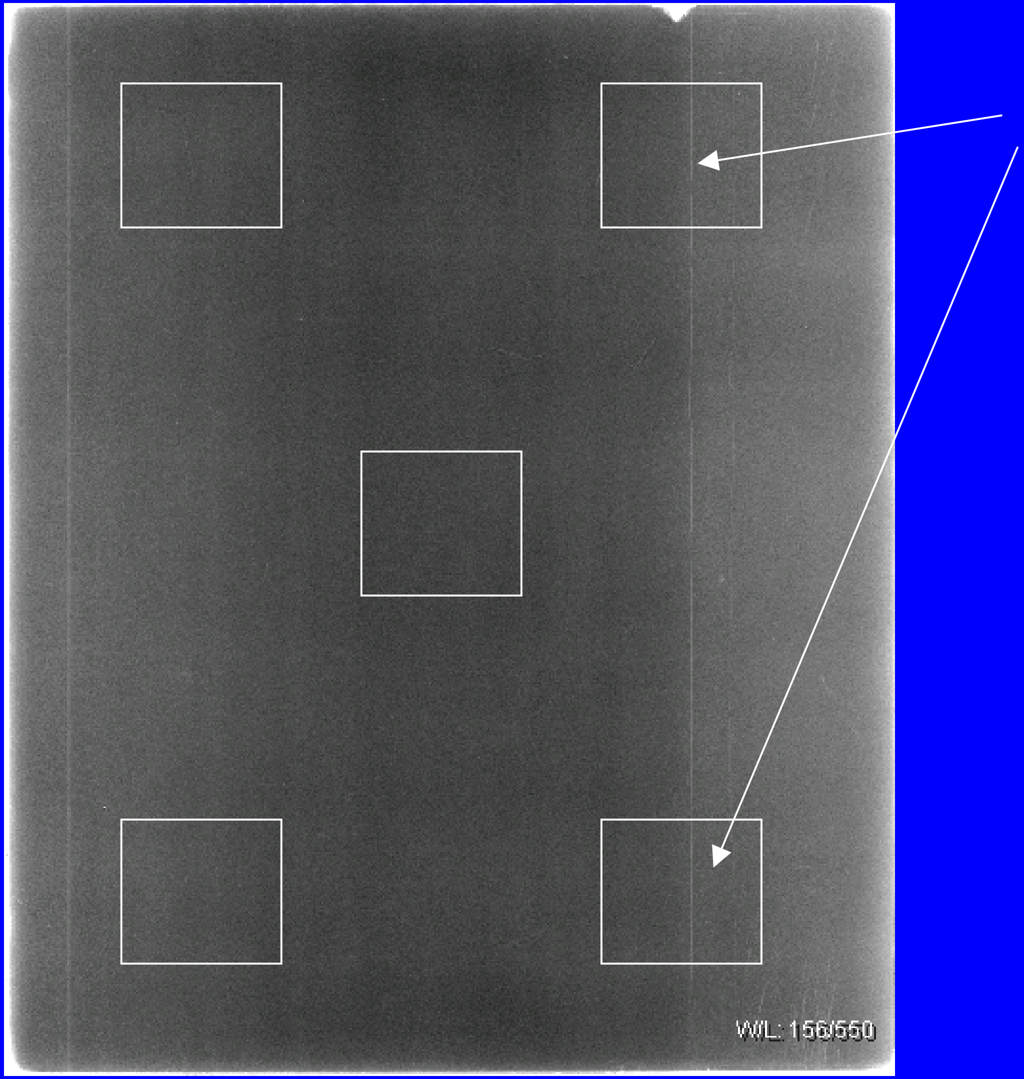
EI	mR
3000	10
2000	1
1000	0.1

Receptor Reproducibility, Density Uniformity and Artifact Analysis

- Use 10-mR images from previous test.
- On an image display workstation use the ROI tool:
  - calculate average digital values at the center and four corners
  - calculate global average of five ROIs
  - determine if each ROI is within 10% of global average
- Examine images for banding, black or white spots, streaks or other artifacts.

W/L: 156/550

ROI Analysis of Density Uniformity

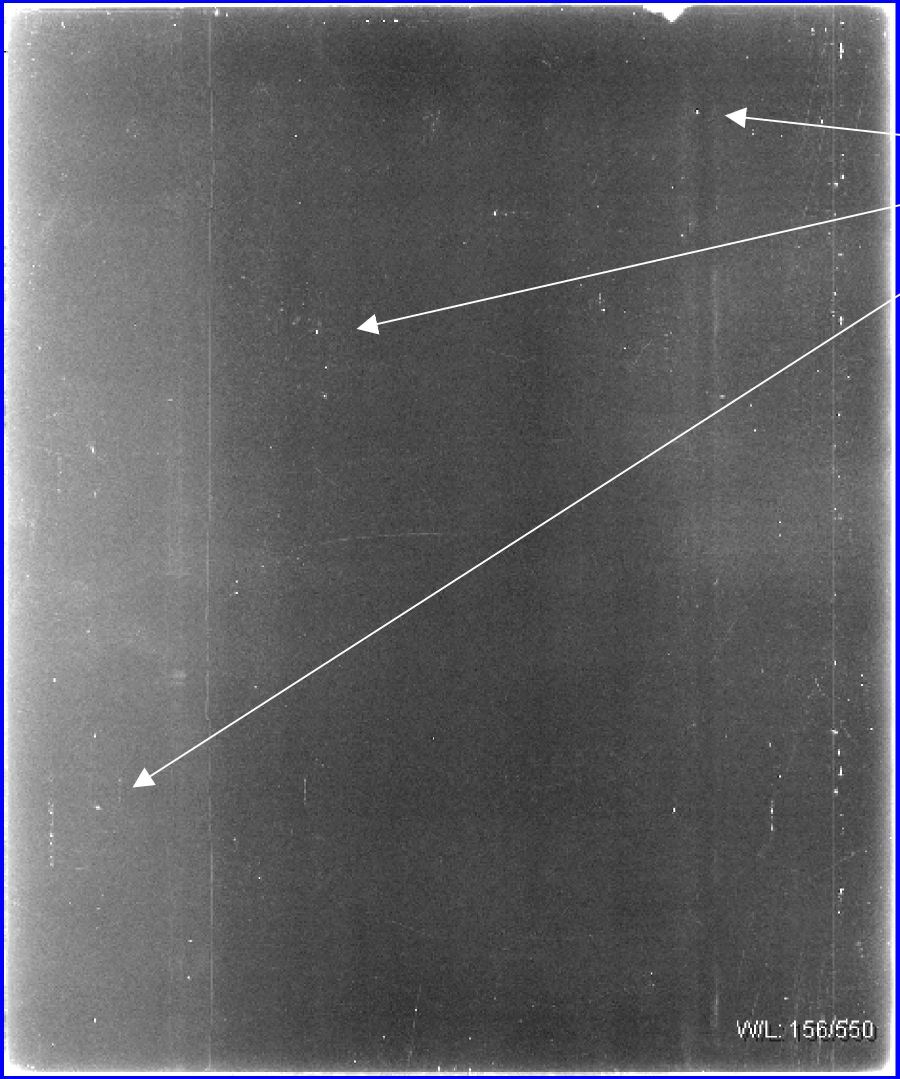


This image fails due to a reader problem.

Failure can also occur due to damaged or contaminated plates (e.g., contrast agent or blood).

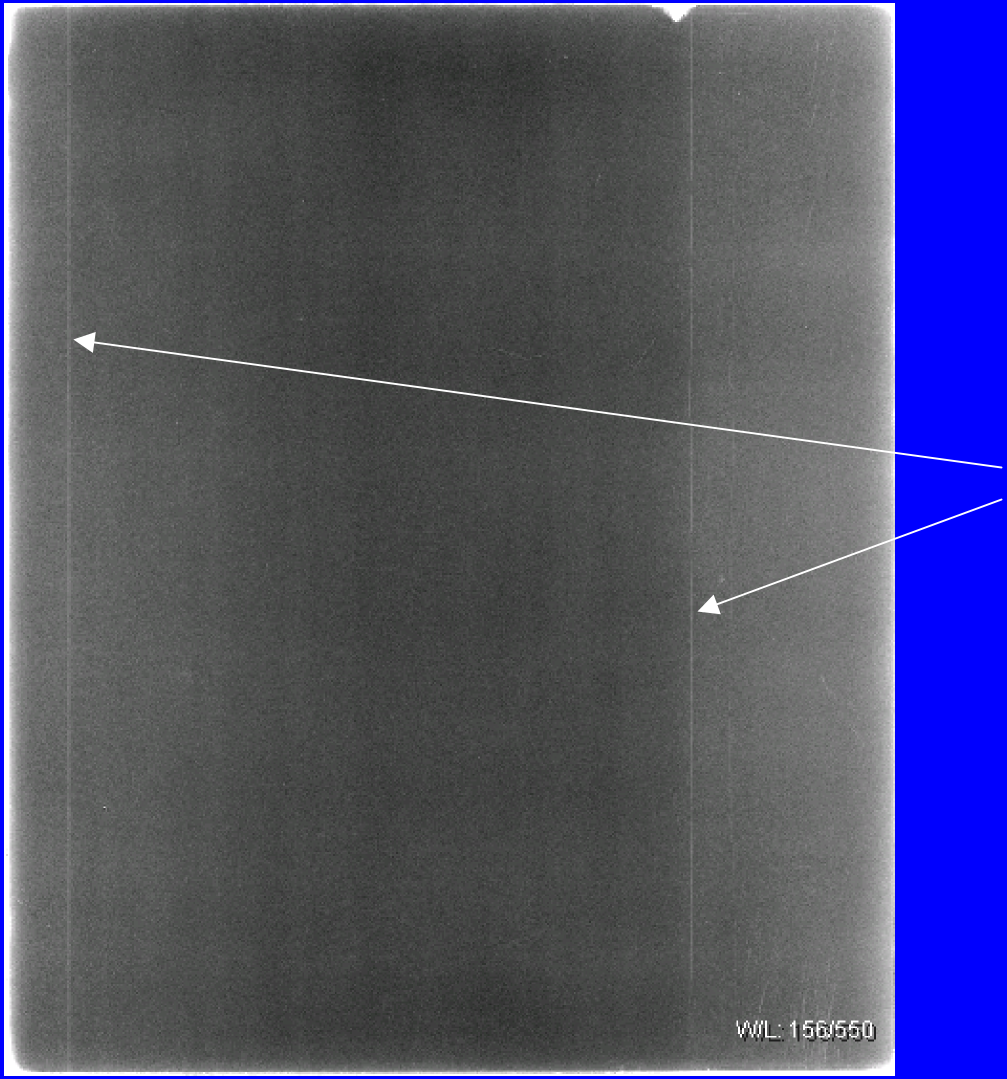
Compares regional means to global mean ±10%.

Artifact Analysis



Dirt on CR image plate displays as minus-density spots.

Artifact Analysis

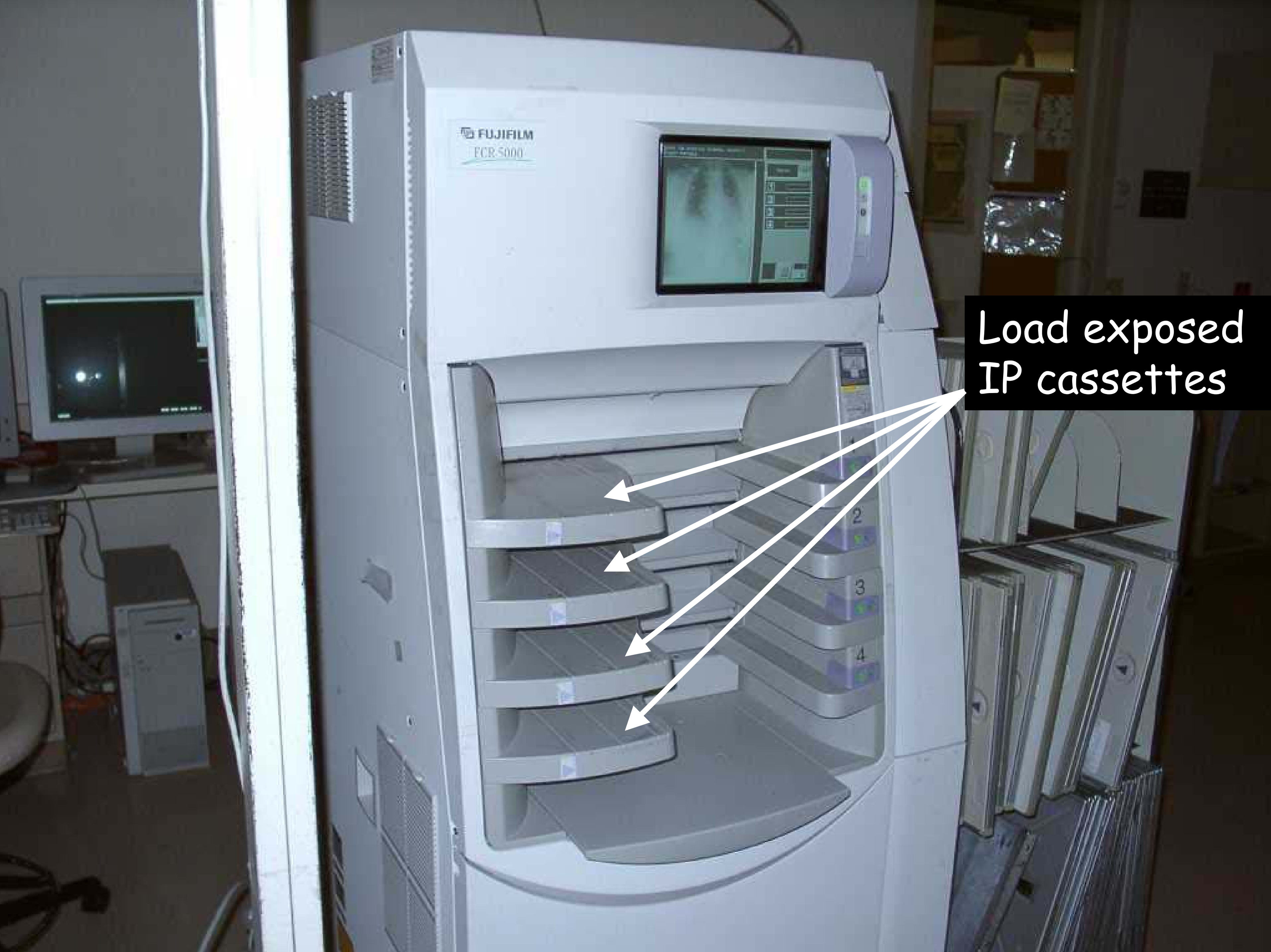


Same image plate after cleaning.

Dust on CR image plate reader light guide causes minus-density lines parallel to direction of image plate movement through reader during readout process.

Phosphor Plate/Cassette Throughput

- Test throughput for each size IP/cassette.
- Expose 6 loaded IP cassettes to a typical diagnostic exposure (1 mR) to exercise the image erase cycle.
- Process the 6 IPs as fast as possible.
- Timing starts when the first image is received at the diagnostic workstation, ends with the arrival of the final image, yielding an elapsed time for five IPs/cassettes .
- Calculate plates per hour throughput.


FUJIFILM
FCR 5000
1
2
3
4

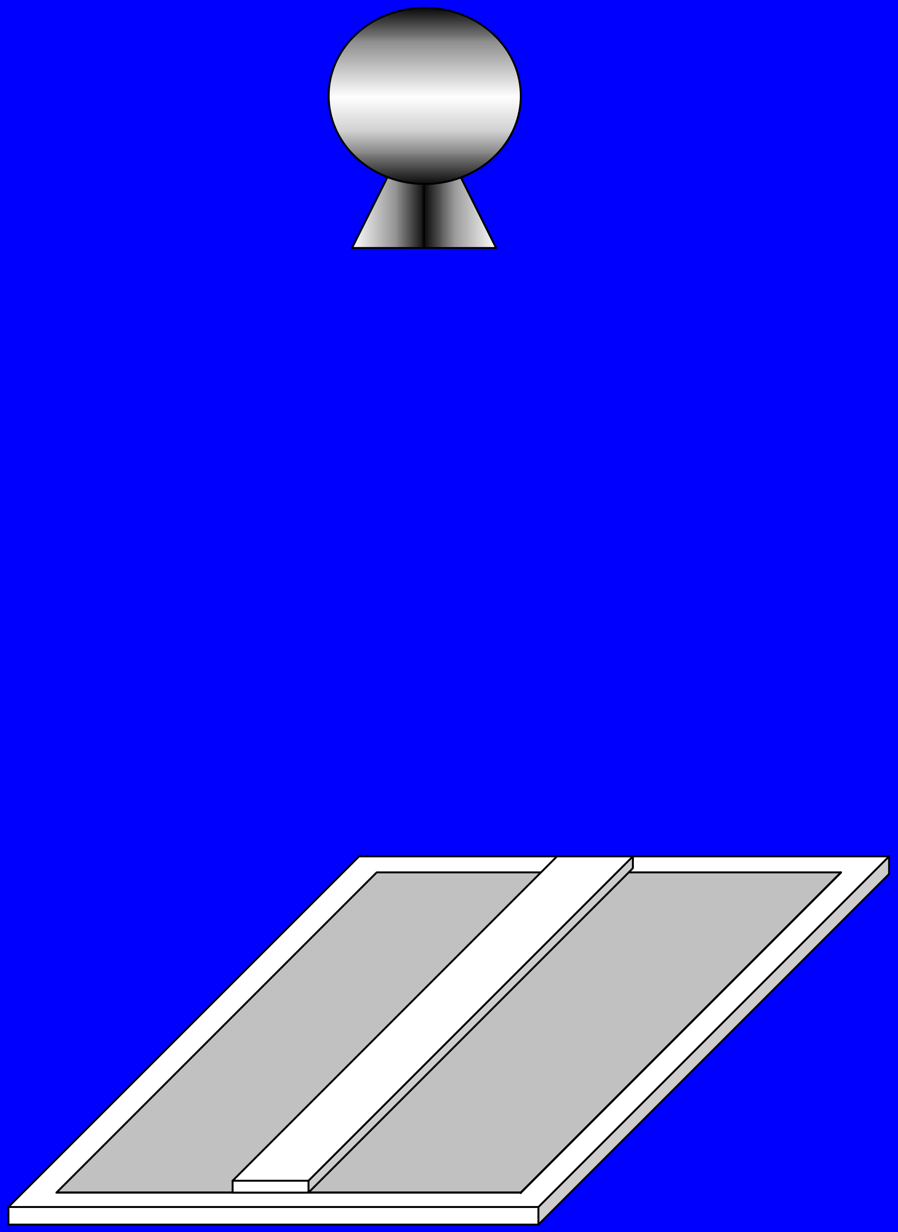
Load exposed IP cassettes

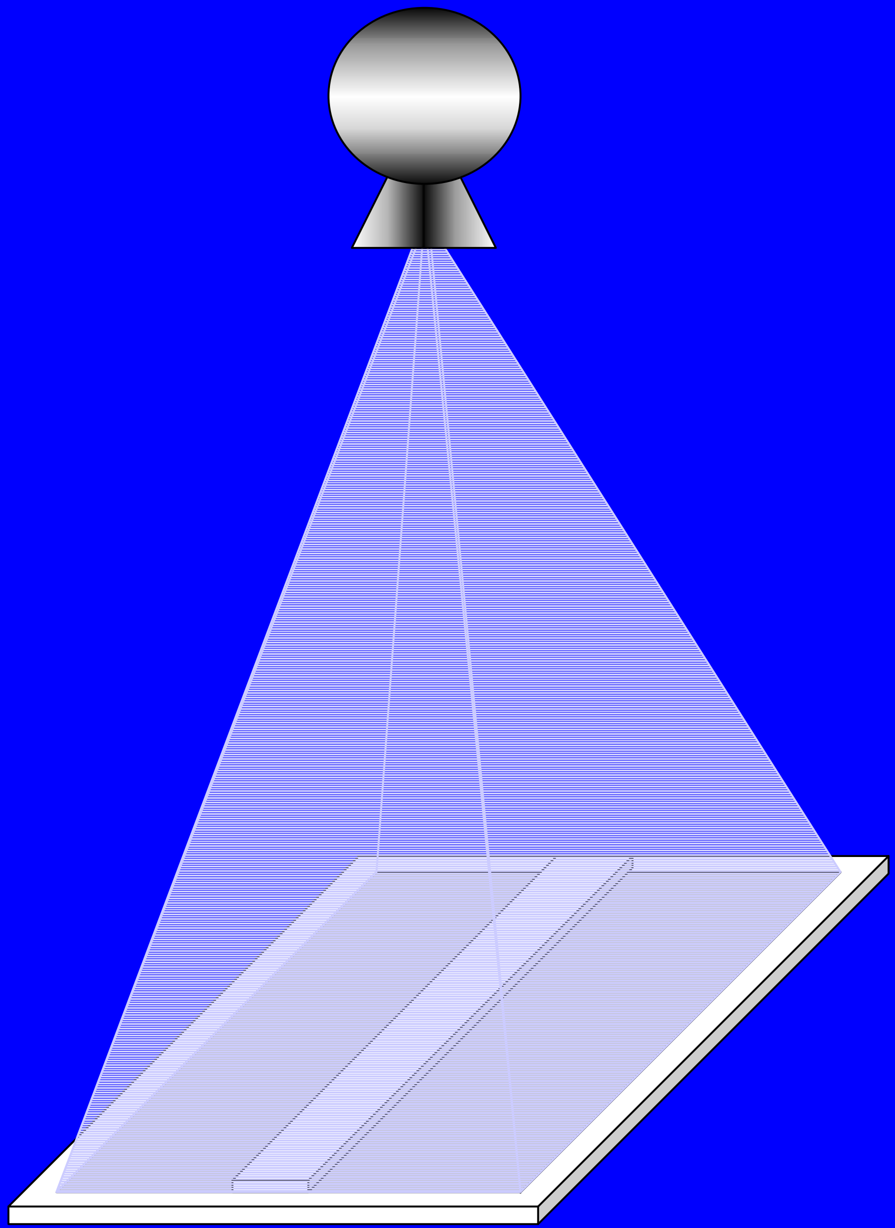
Laser Beam Function

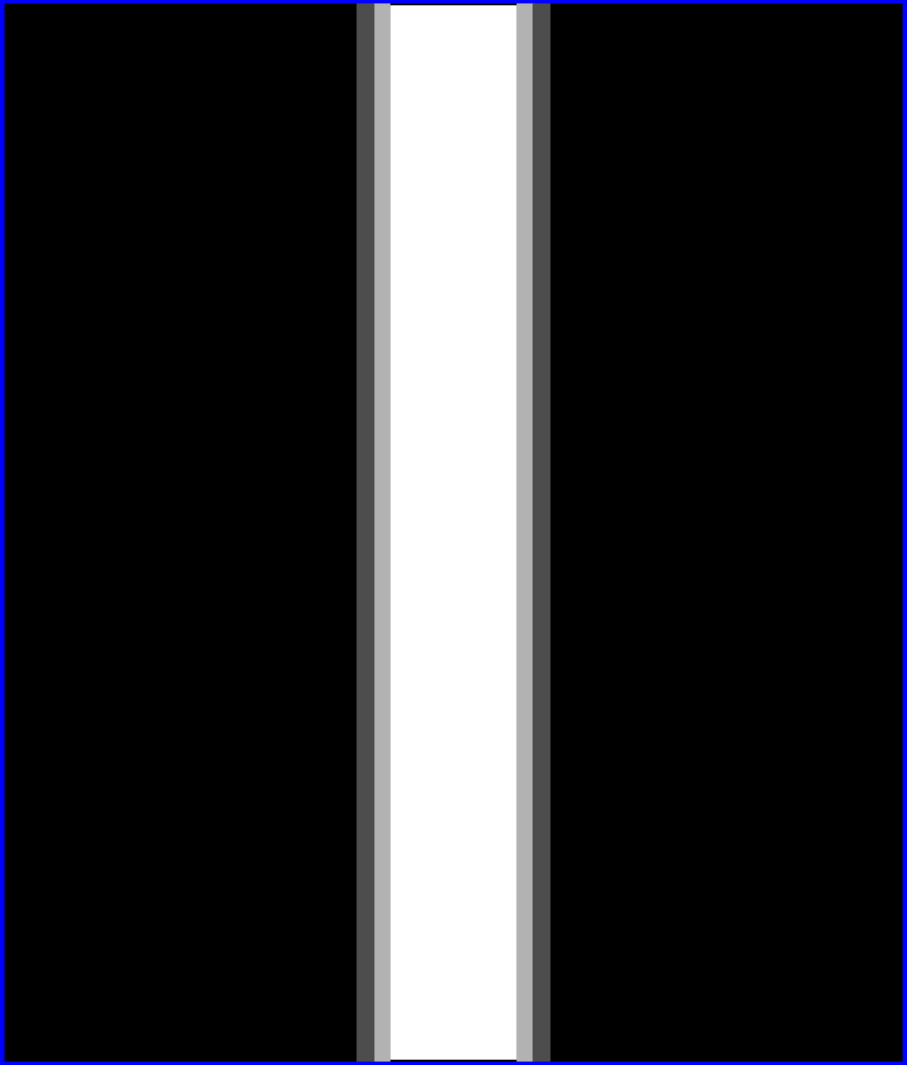
- Determine the reader laser scan direction for each cassette in use.

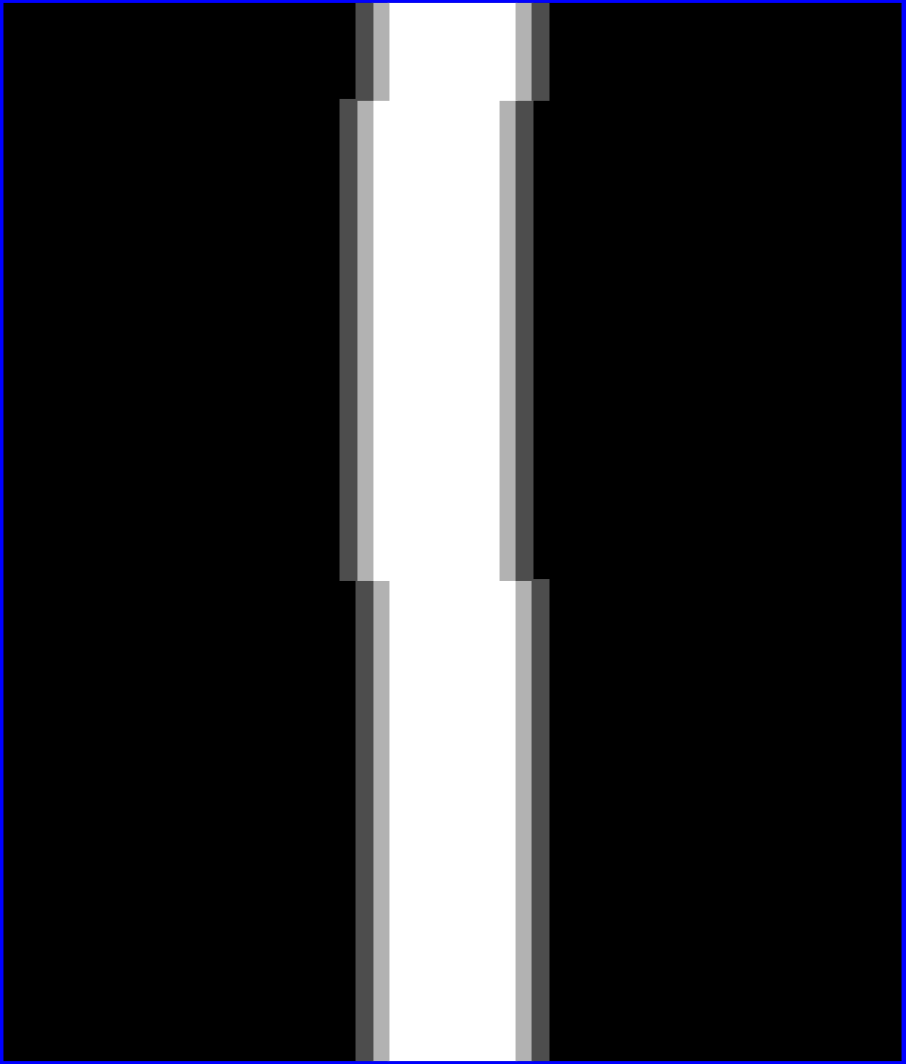
- Make an x-ray image of a steel ruler on each cassette with the ruler perpendicular to the laser scan direction.
  - Use a radiographic technique of 80 kVp and 180 cm SID
  - Deliver an incident exposure of 5 mR

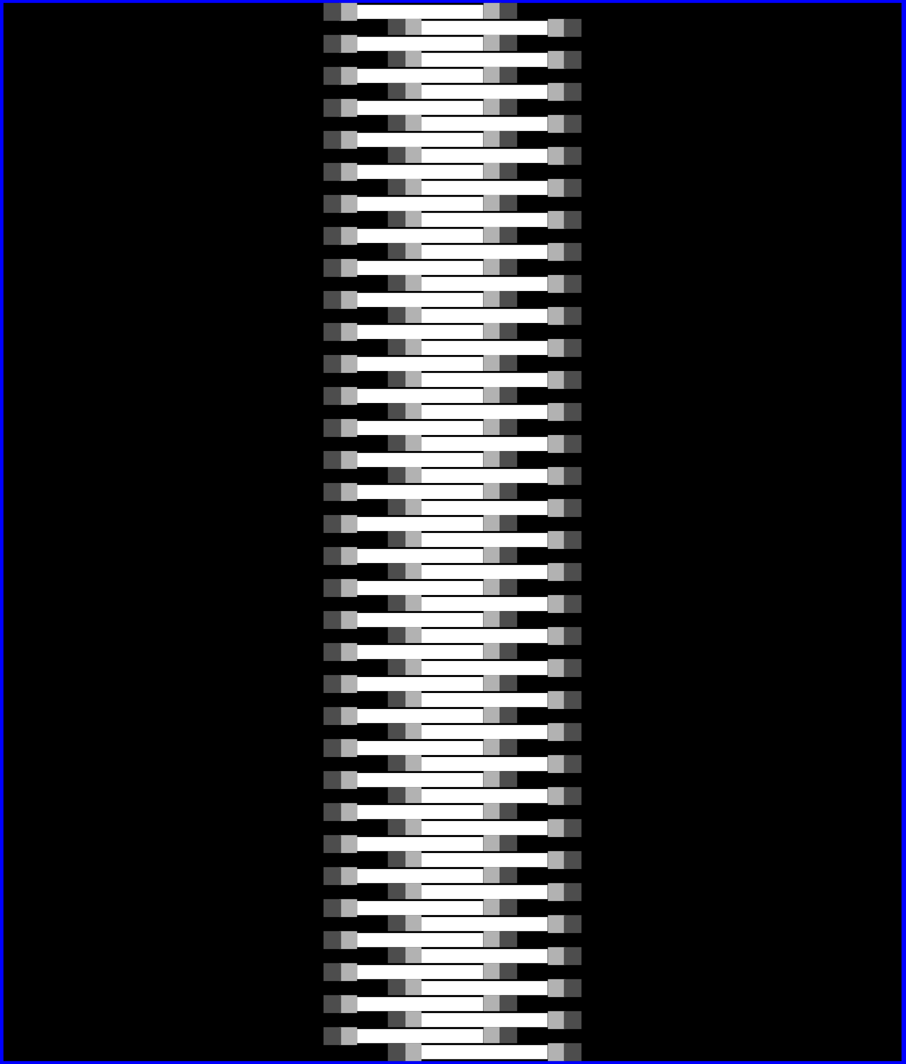
- The image should have sharp straight edges (no greater than one pixel displacement error).









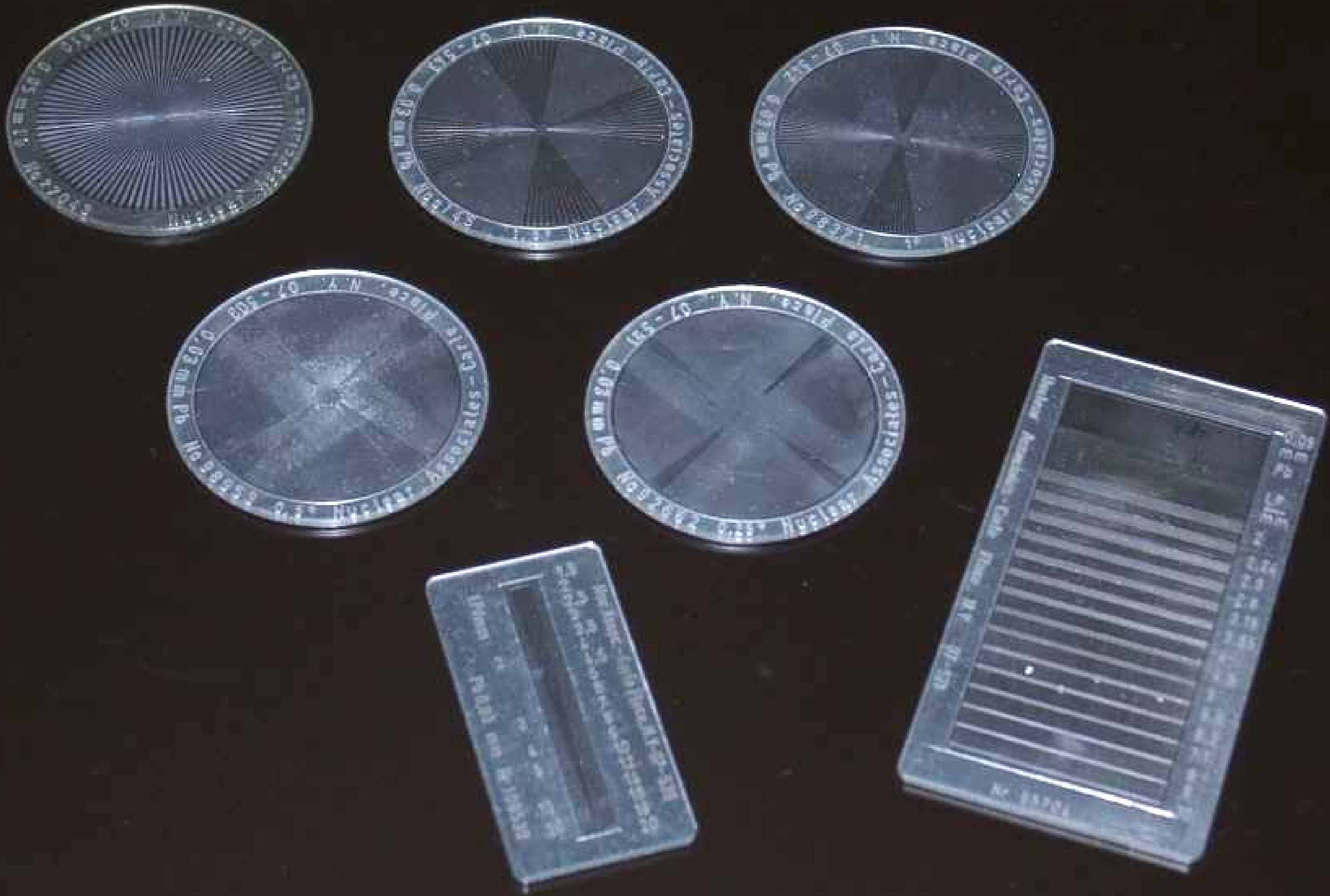


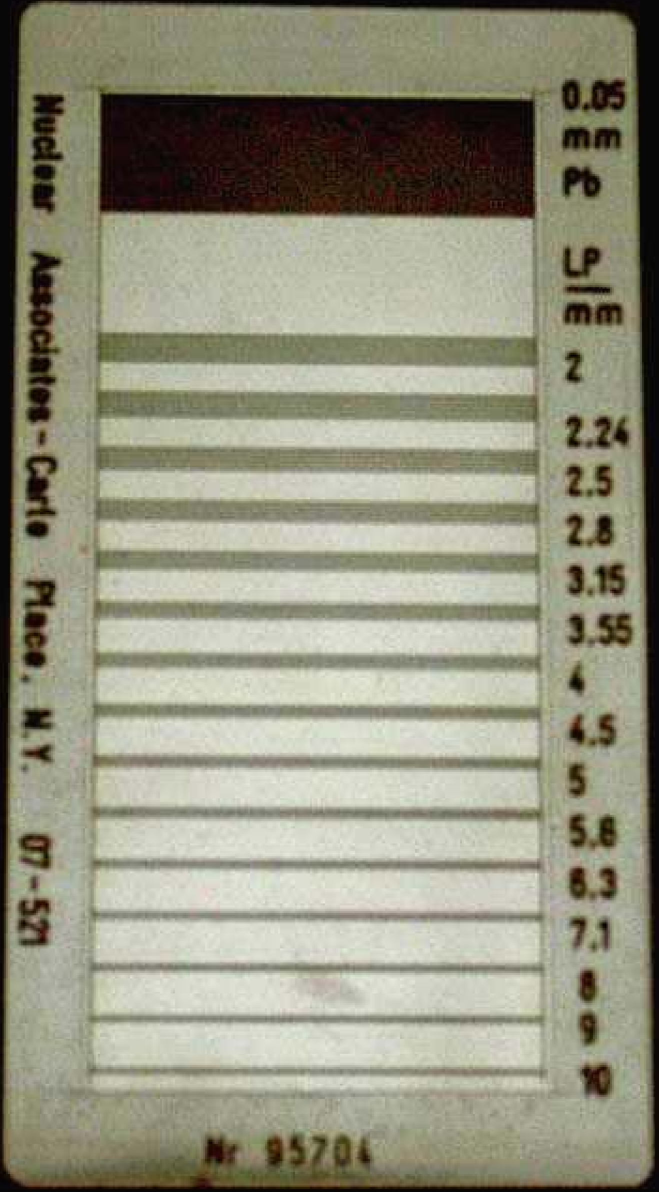
Spatial Resolution

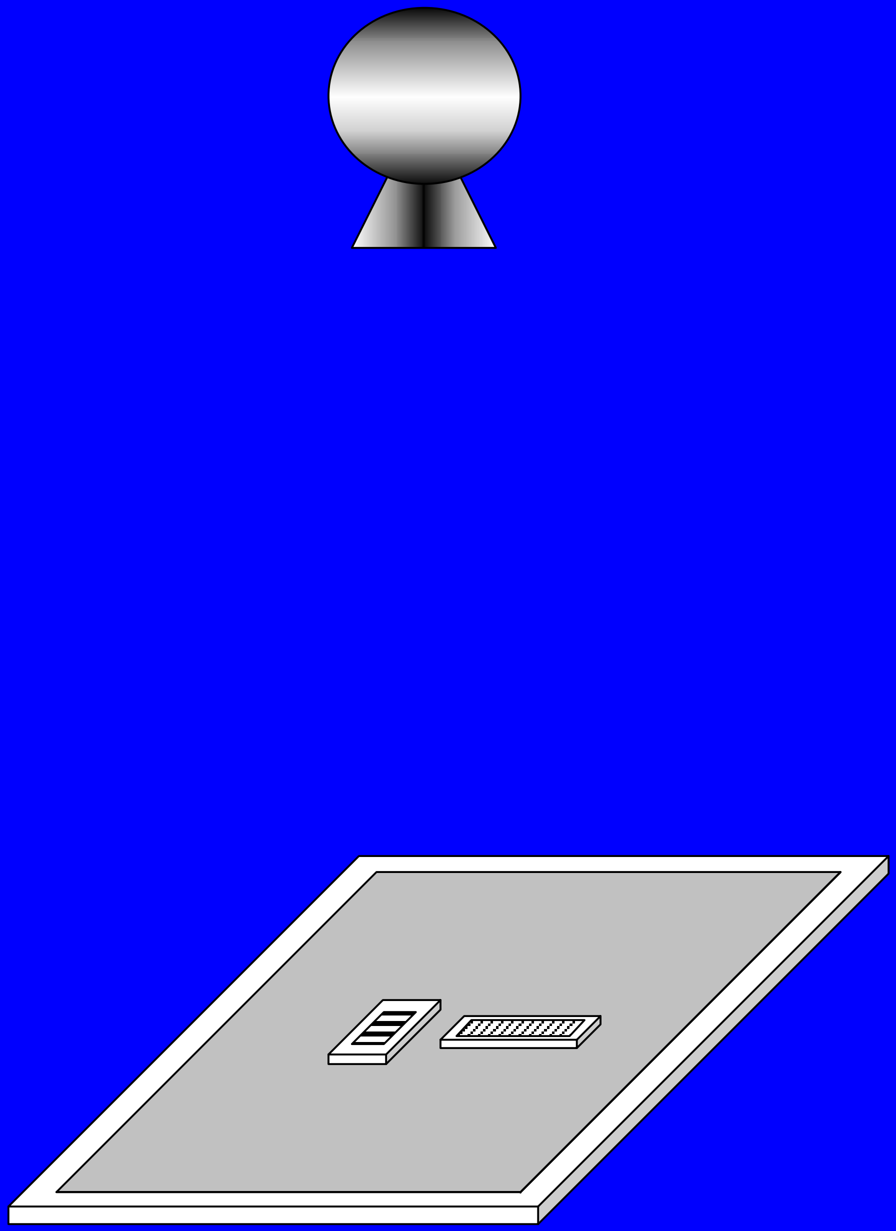
- Place two lead bar square-wave resolution test phantoms (2.5 to 5.0 lp/mm) on each size IP/cassette
  - one parallel to laser scan direction (plate position accuracy)
  - one parallel to plate travel direction (mirror registration accuracy)

- Expose each cassette using 60 kVp at 180 cm SID to deliver 5 mR to the cassette surface.

- View test patterns on the image display workstation.
  - standard ±10% of the limiting resolution specification
  - specification depends on instrument design, cassette size, etc.




Nuclear Associates - Carle Place, N.Y. 07-521
0.05 mm Pb
LP/mm
2
2.24
2.5
2.8
3.15
3.55
4
4.5
5
5.6
6.3
7.1
8
9
10
Nr 95704



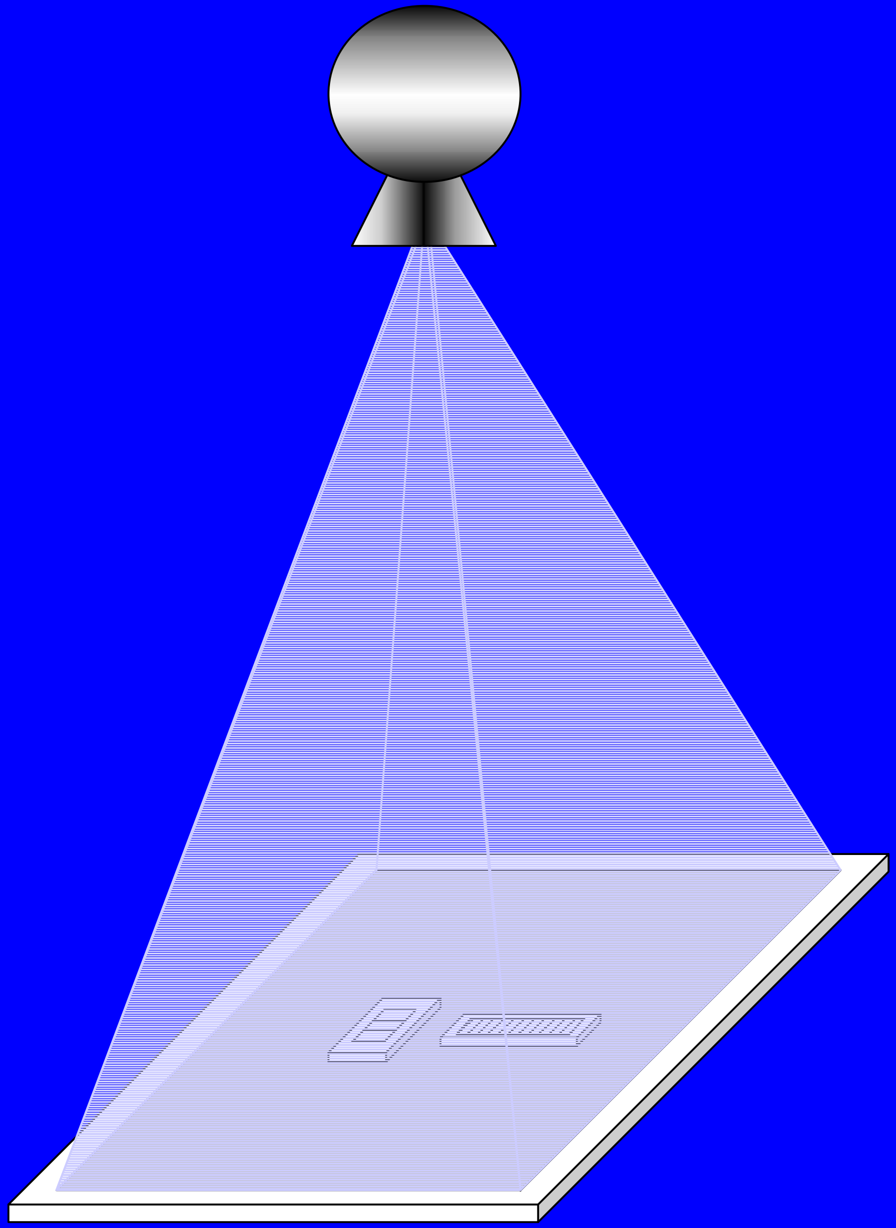
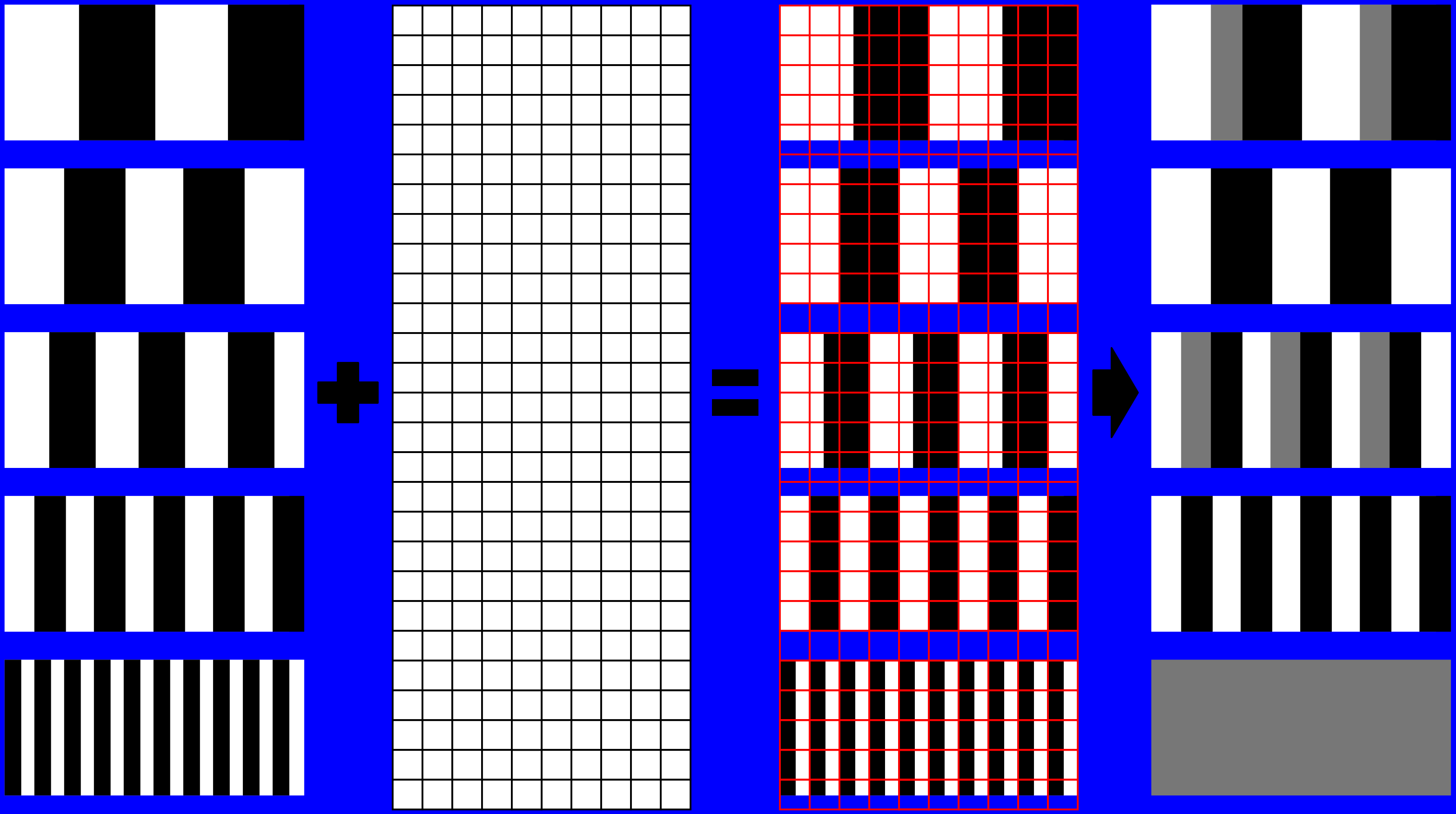
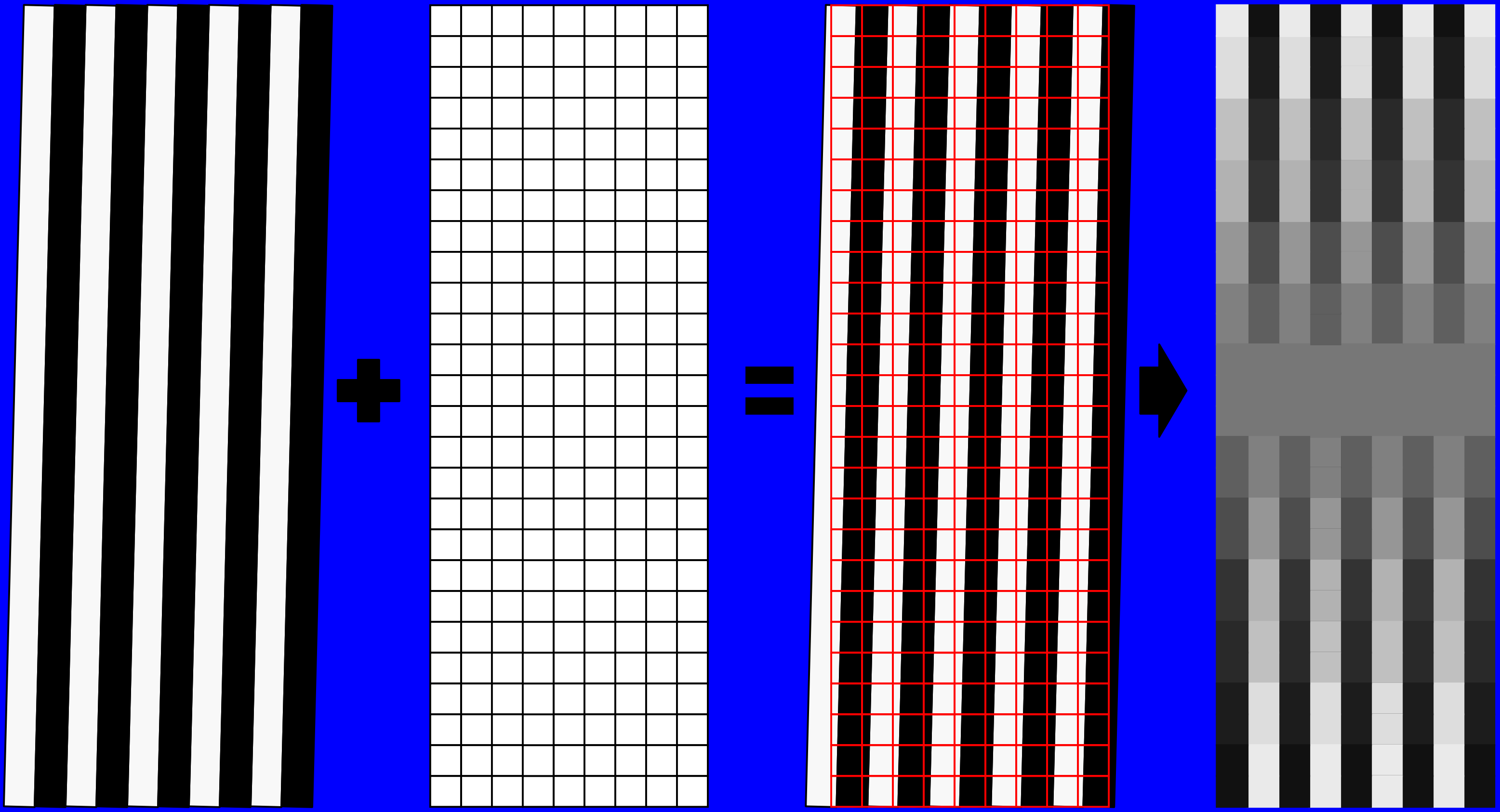
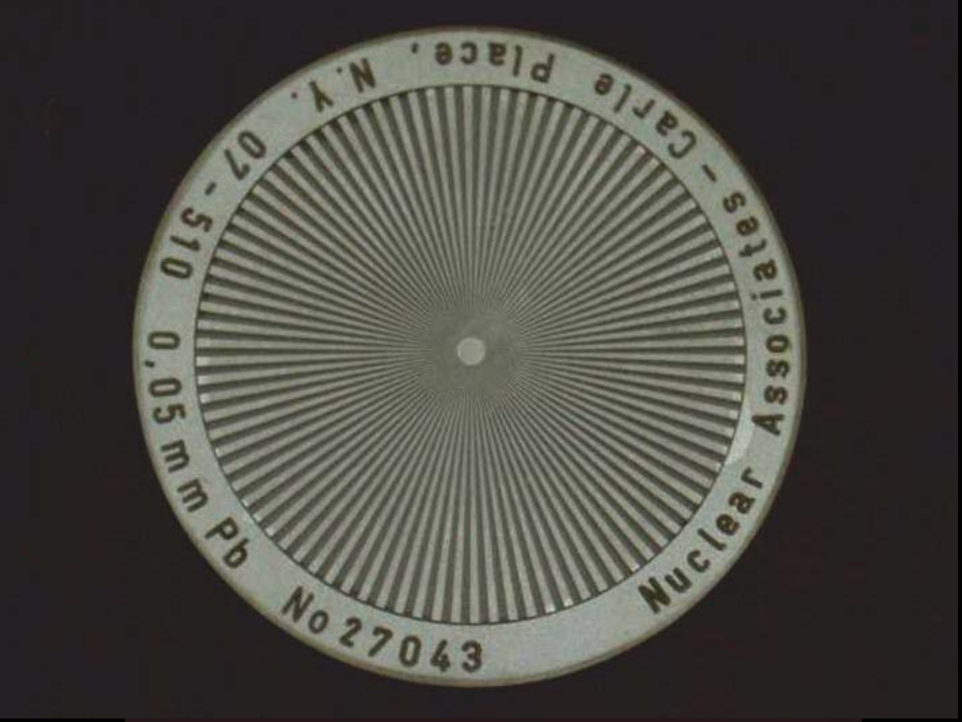
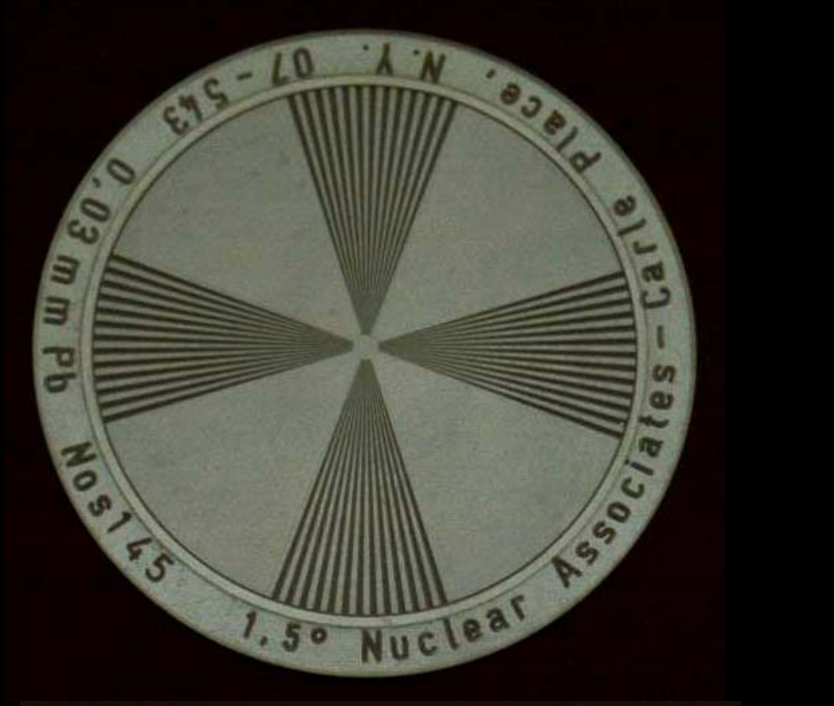


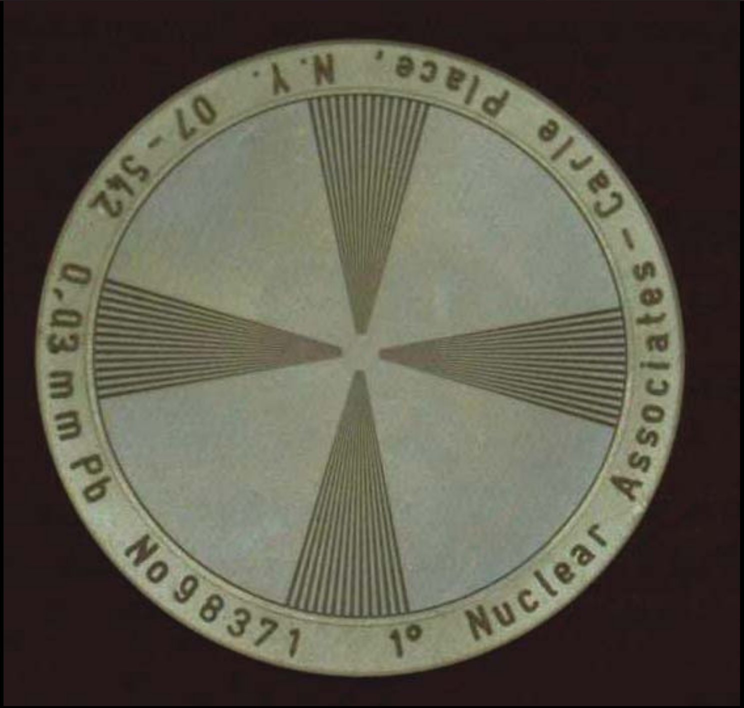
Image & Readout Matrices Coincide

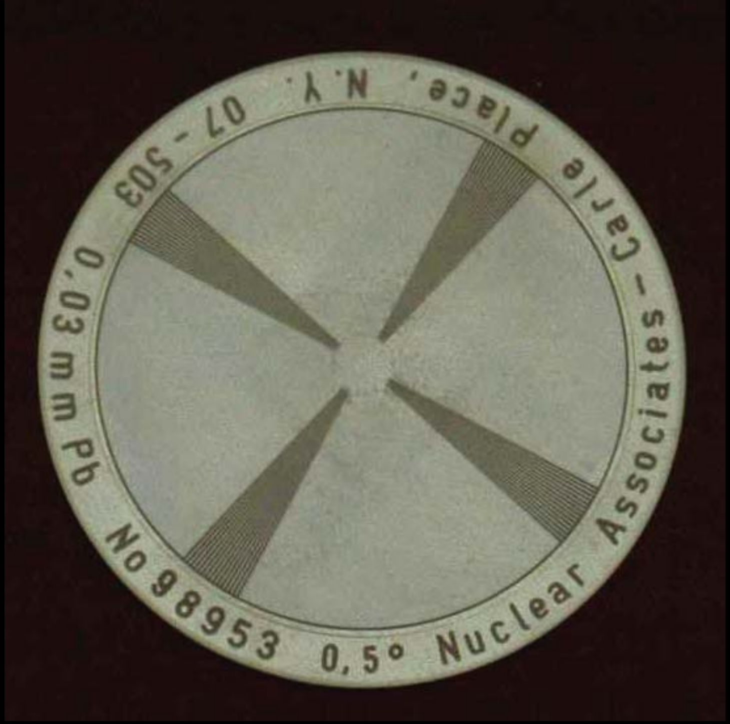


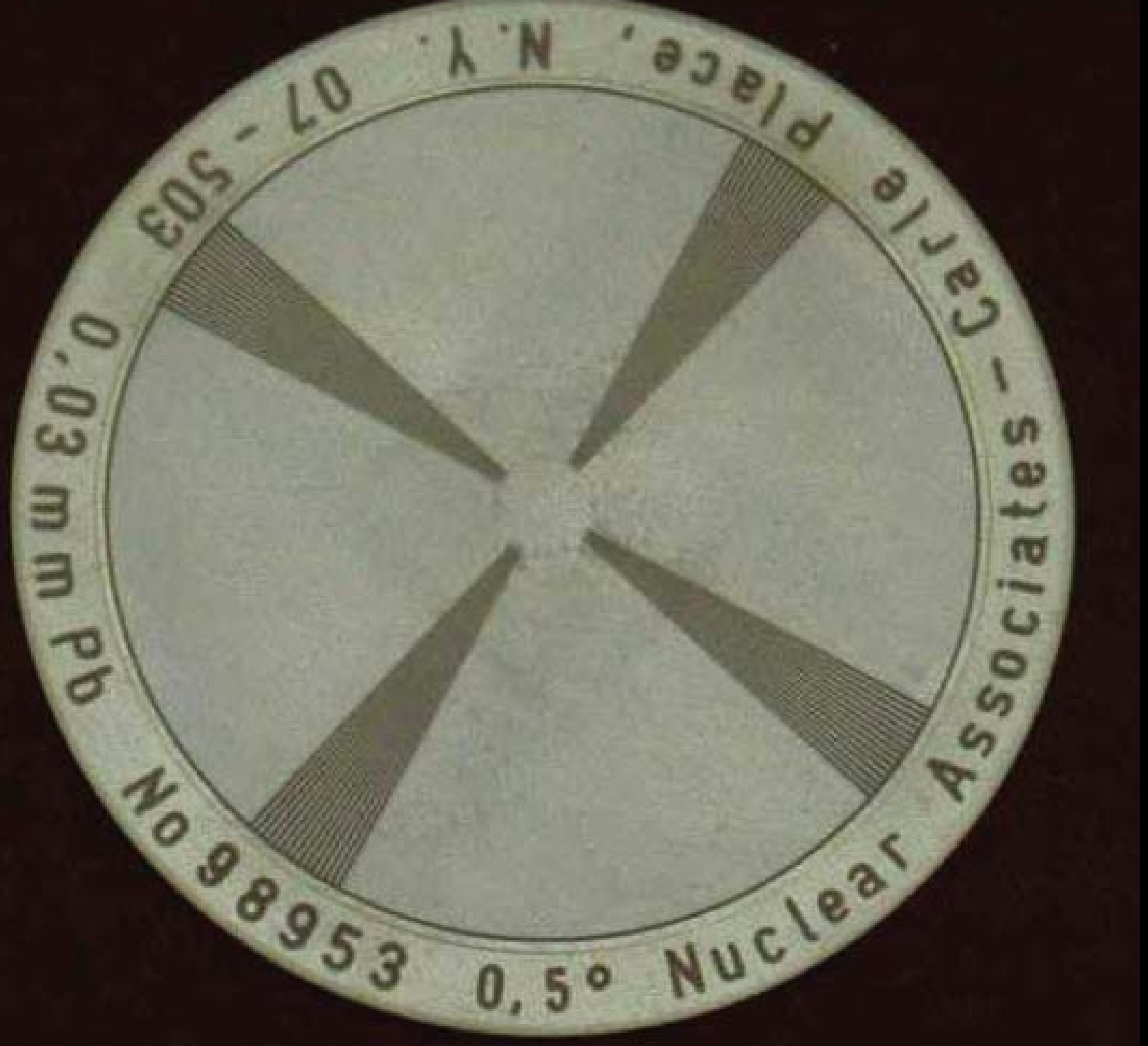


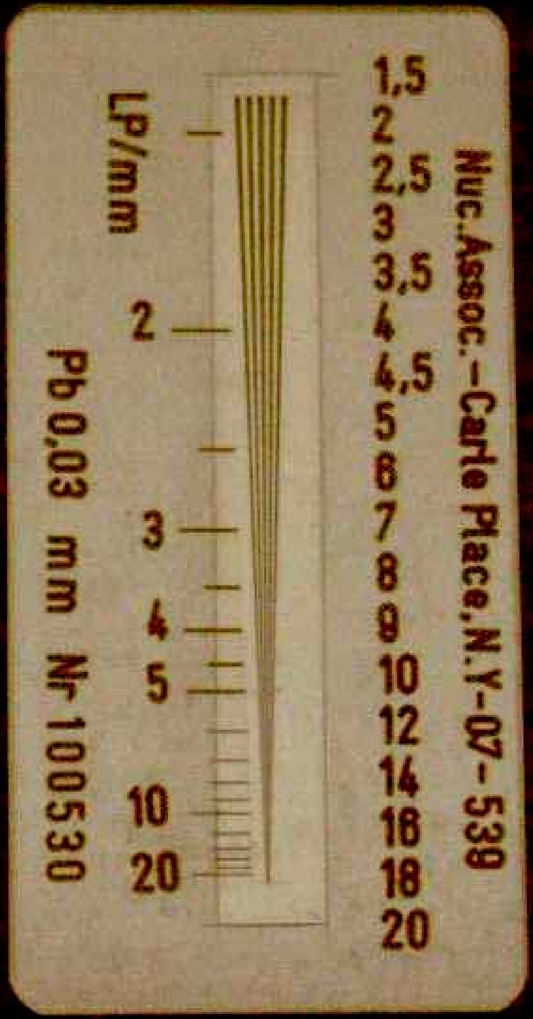

Nuclear Associates - Carle Place, N.Y. 07-510
0,05 mm Pb
No 27043

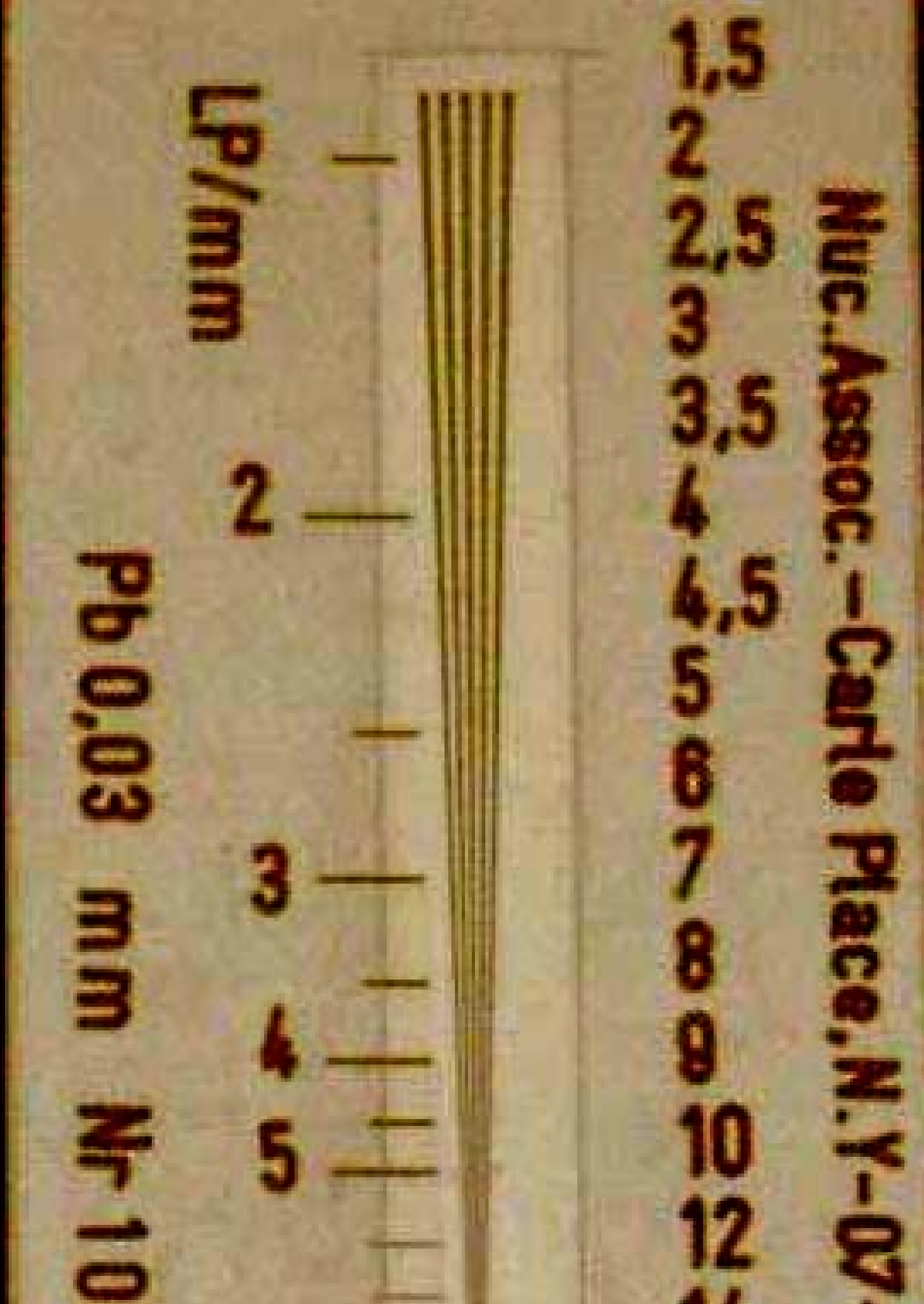

1,5° Nuclear Associates - Carle Place, N.Y. 07-543
0,03 mm Pb
Nos145


1° Nuclear Associates - Carle Place, N.Y. 07-542
0,03 mm Pb
No98371


0,5° Nuclear Associates - Carle Place, N.Y. 07-503
0,03 mm Pb
No98953

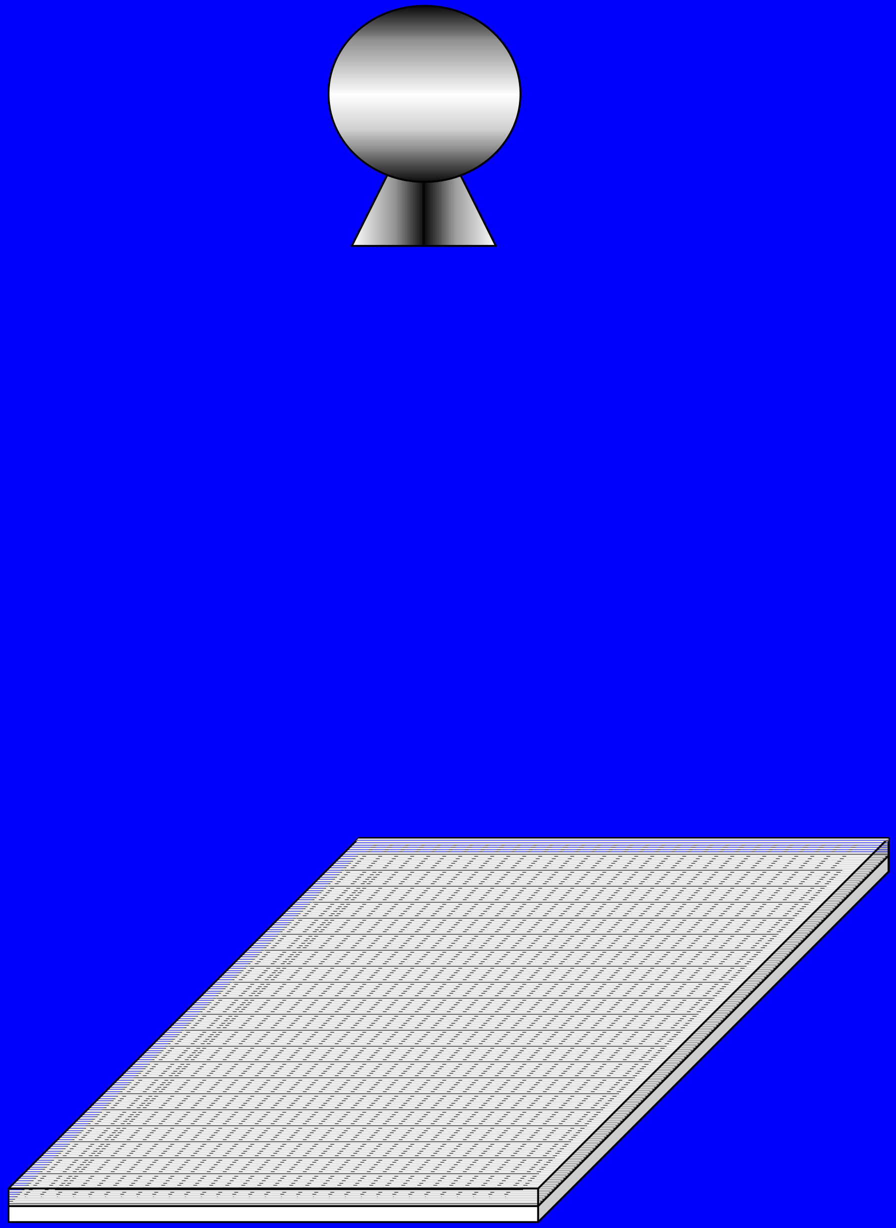

No 98953 0,5° Nuclear Associates – Carle Place, N.Y. 07-503 0,03 mm Pb

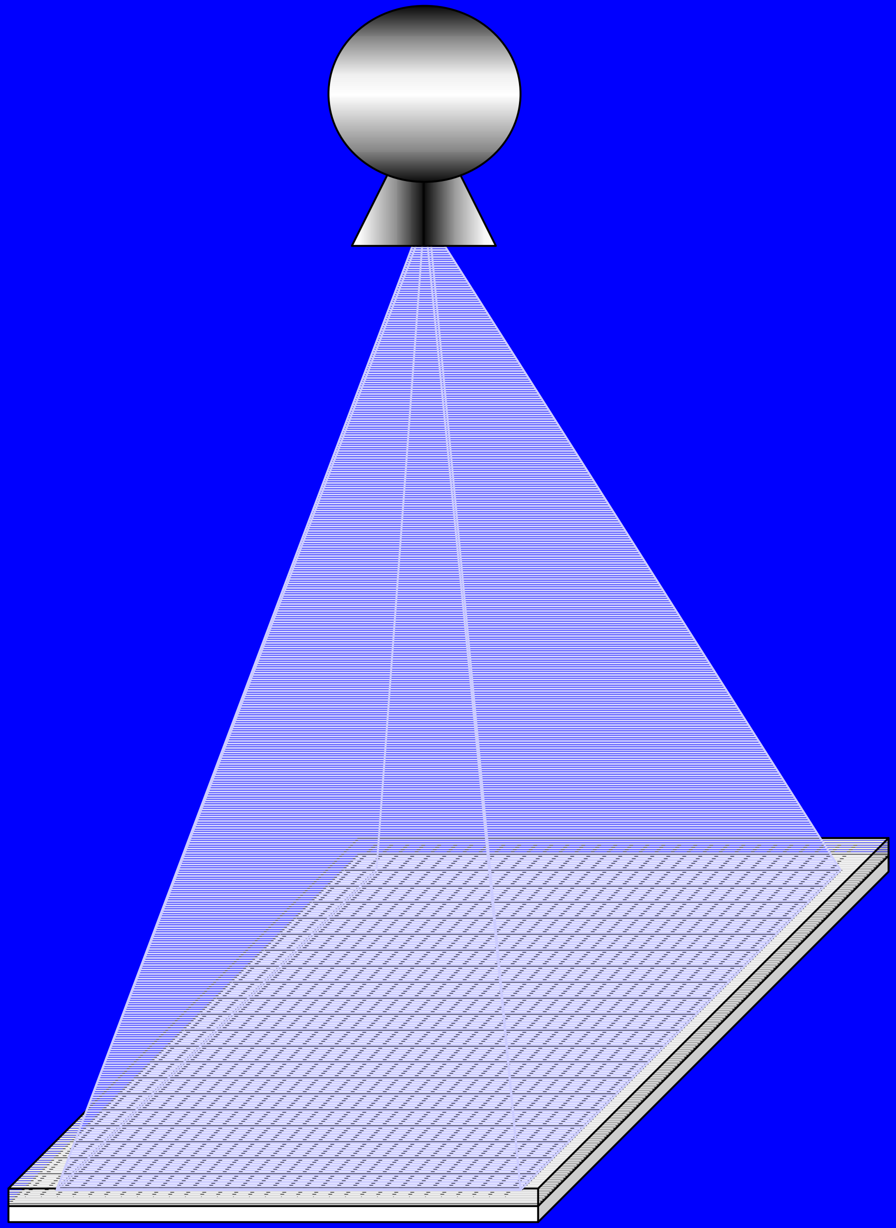

LP/mm
2
3
4
5
10
20
1,5
2
2,5
3
3,5
4
4,5
5
6
7
8
9
10
12
14
16
18
20
Nuc.Assoc.-Carle Place,N.Y-07-539
Pb 0,03 mm Nr 100530

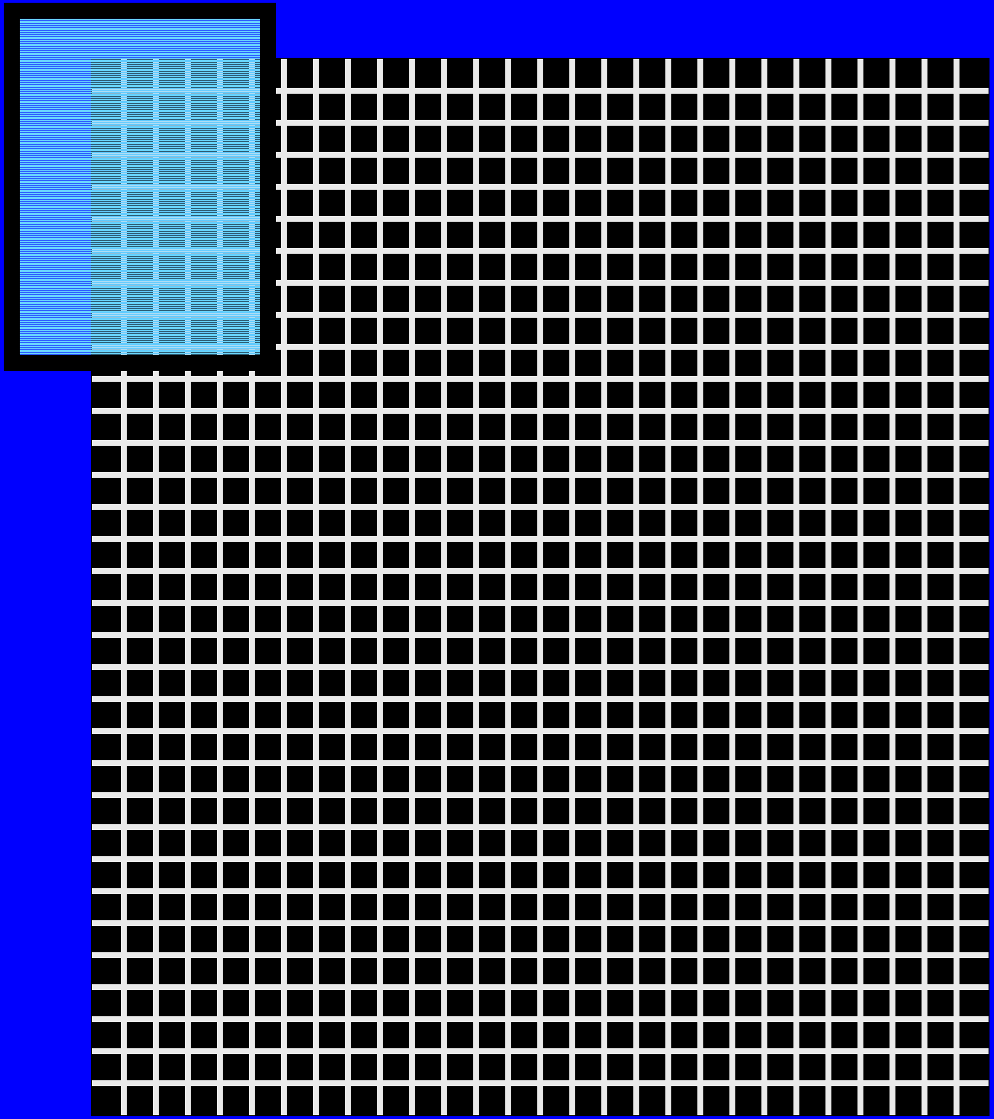

LP/mm
2
3
4
5
1,5
2
2,5
3
3,5
4
4,5
5
6
7
8
9
10
12
Nuc.Assoc.-Carle Place,N.Y-07
Pb0,03 mm Nr 10

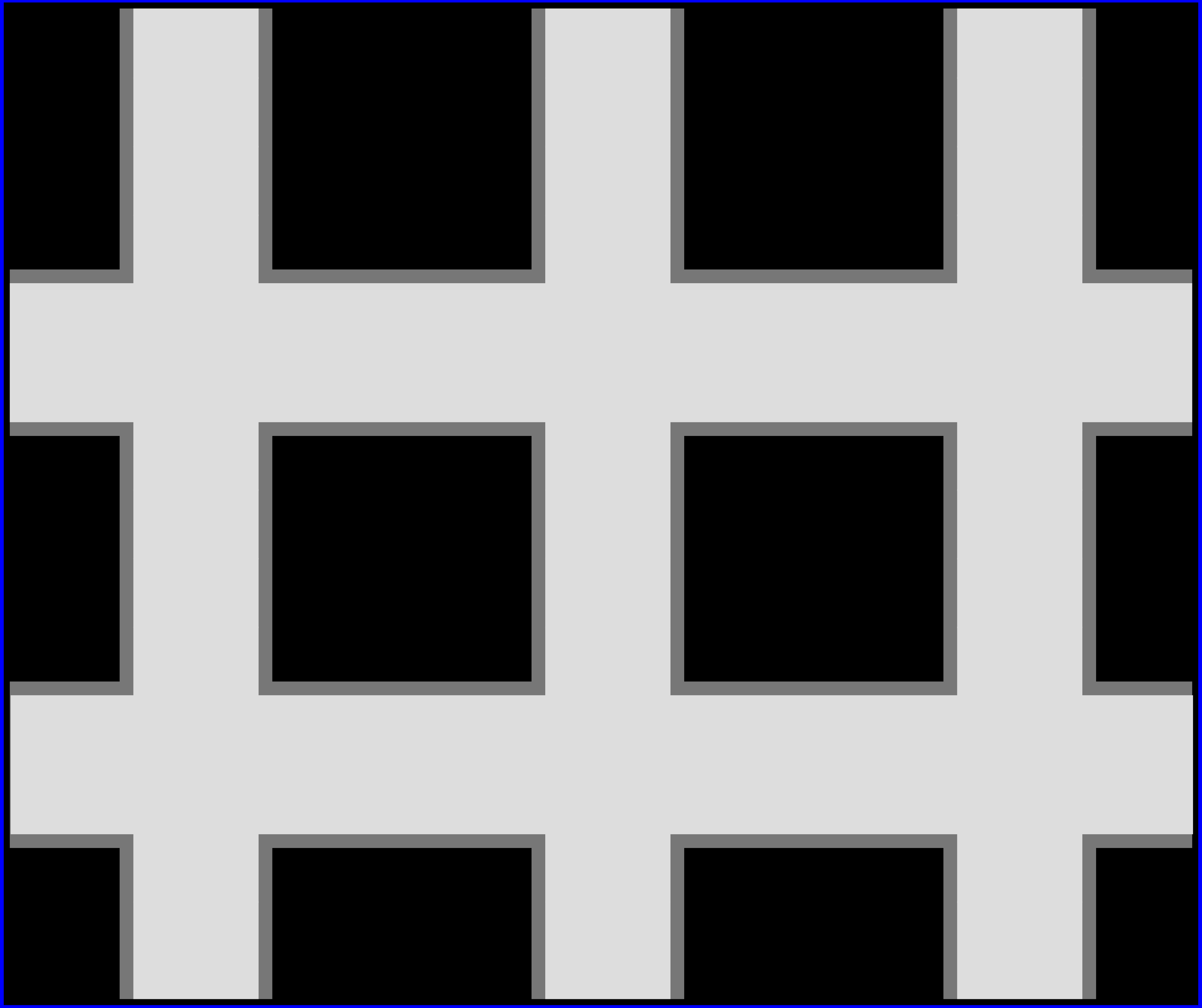
Wire Mesh Test and Resolution Uniformity Across the Receptor

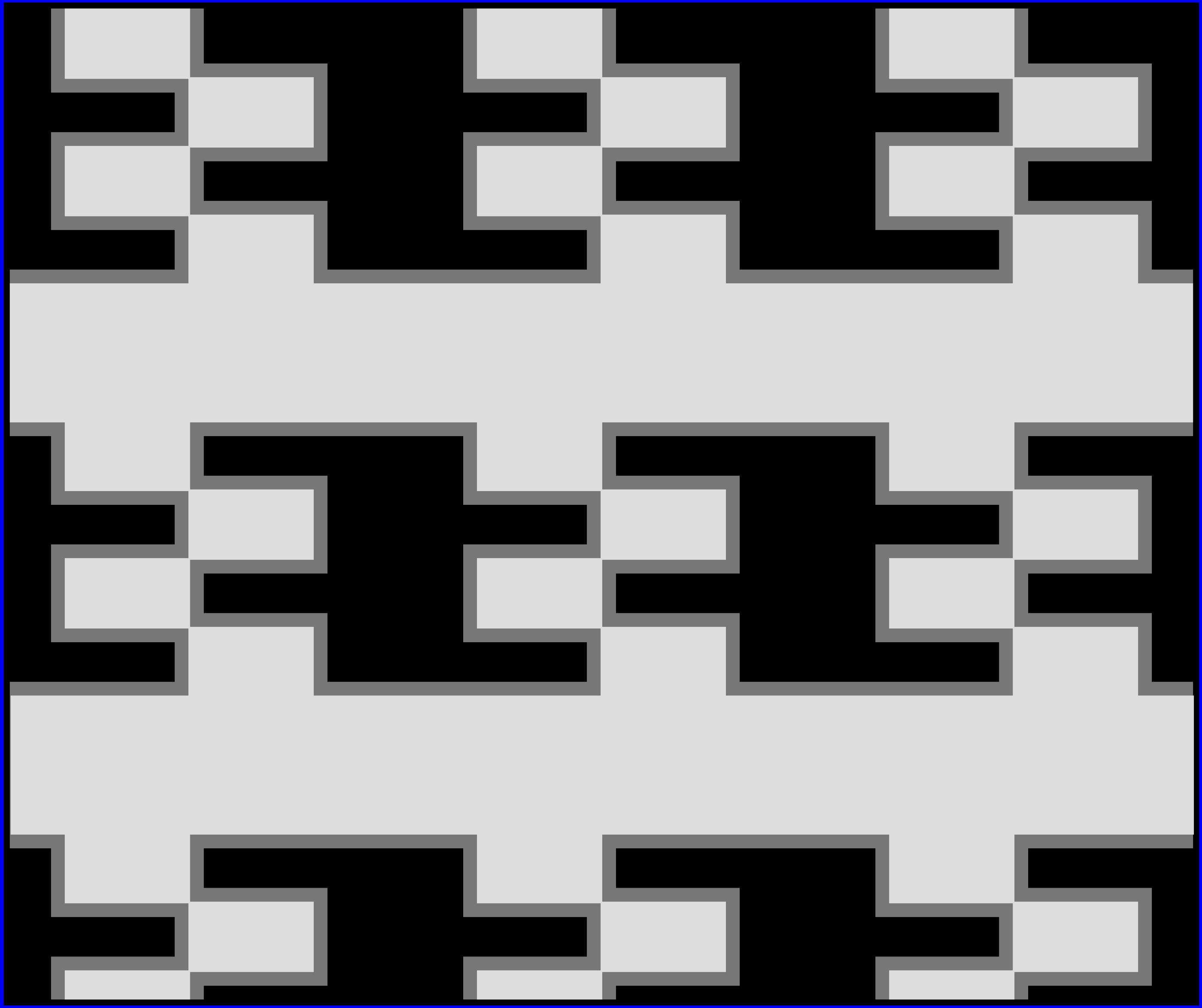
- Image the wire mesh test tool in direct contact with the face of the cassette (one of each size in common use).
- Expose the cassette to 5 mR (60 kVp, 180 cm SID).
- View test pattern on the image display workstation
  - Look for geometric distortion
  - Look for uniform sharpness







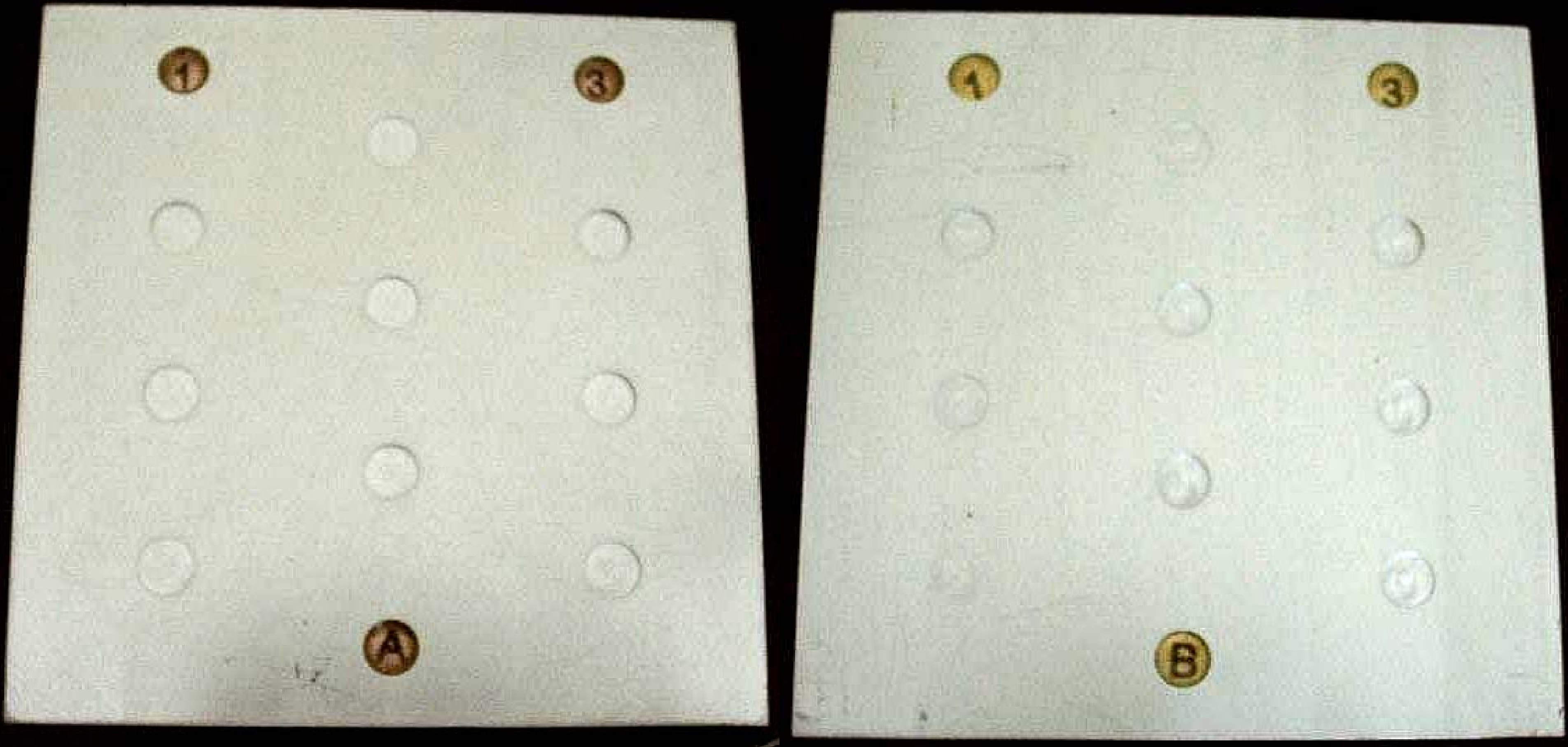




Low Contrast Sensitivity/Detectability

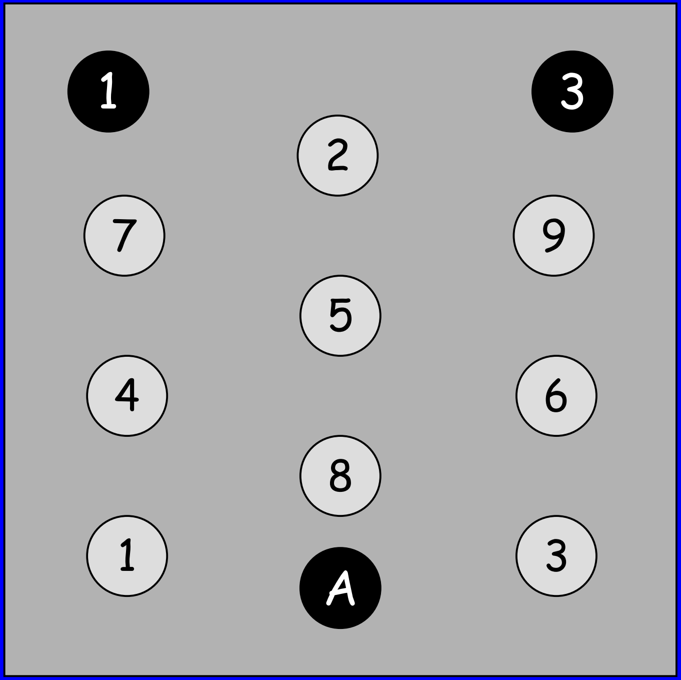
- Image the University of Alabama low contrast phantom to measure contrast sensitivity for one of each size cassette in common use.
  - phantom placed on the face of the cassette
  - beam filtered at the collimator by additional 2 mm of copper
  - exposure recalibrated to give 0.1, 1.0, and 10 mR to the IP
  - use 80 kVp, 180 cm

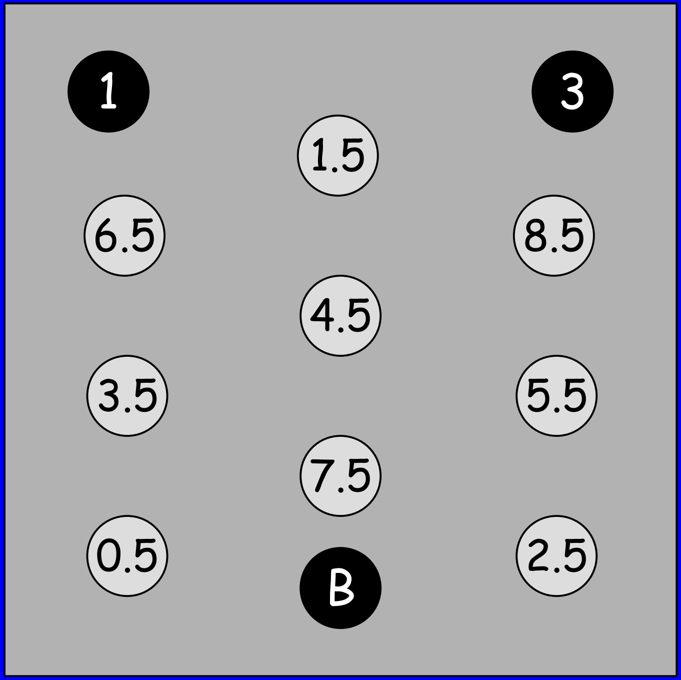
- Score the images to determine low contrast sensitivity.


1
3
A
1
3
B

Scoring

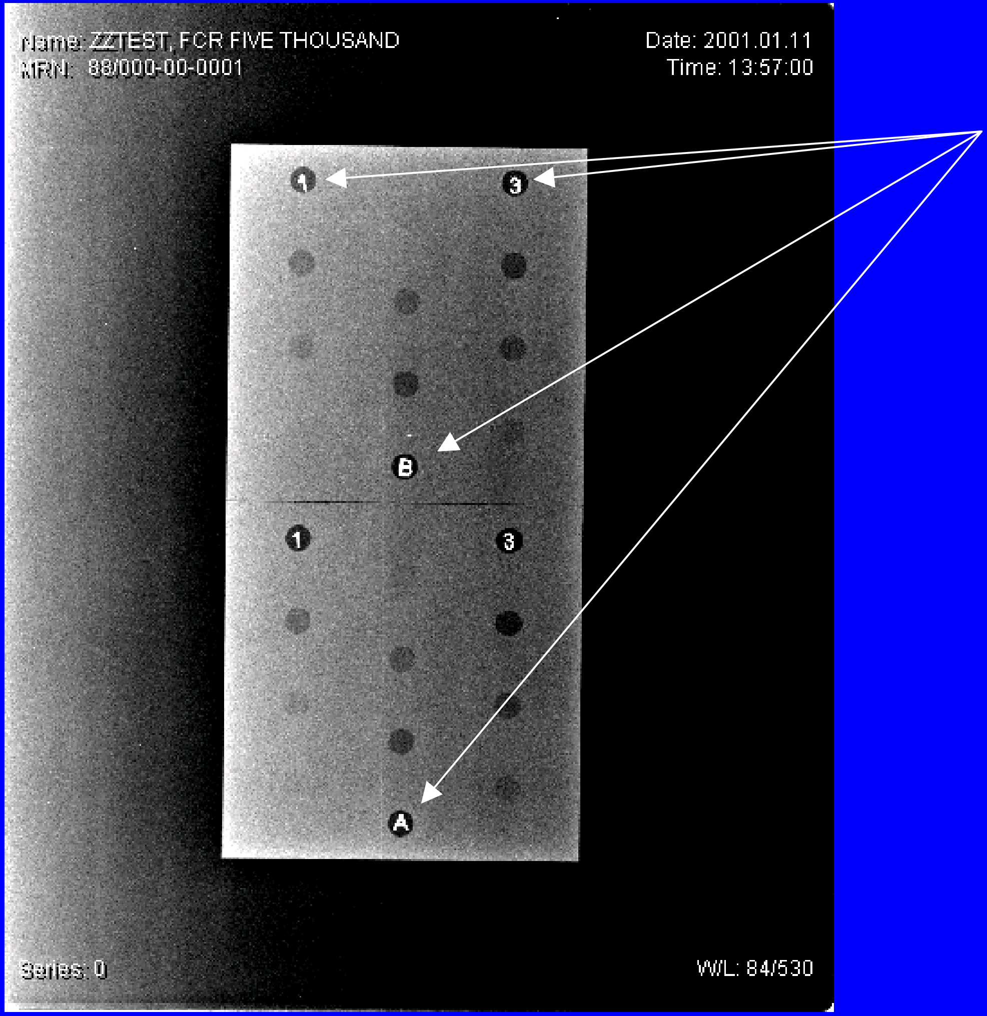
The values shown are percent contrast sensitivity.


1
3
2
7
9
5
4
6
8
1
3
A


1
3
1.5
6.5
8.5
4.5
3.5
5.5
7.5
0.5
2.5
B

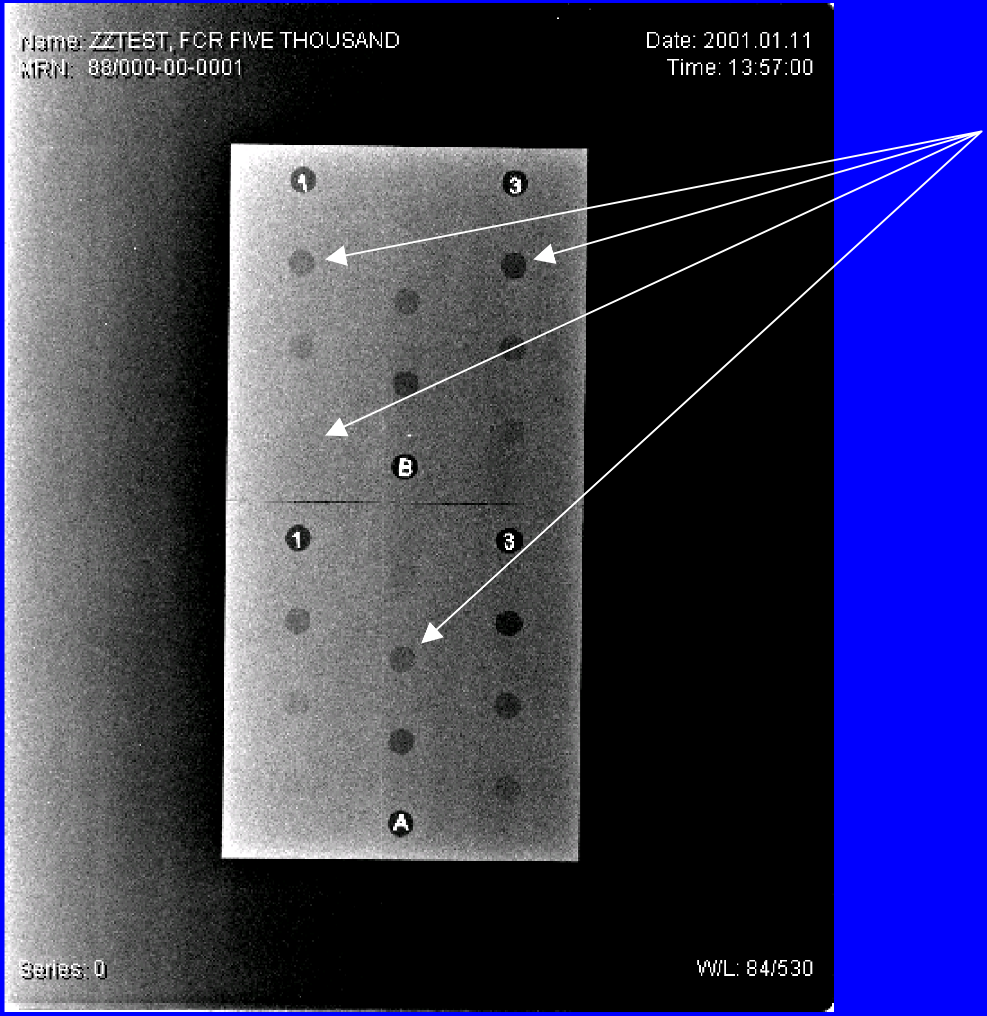
- Primarily used to evaluate change from acceptance baseline.
- BAMC recommends 2% or less for an exposure of 1 mR.

Image of UAB Test Tool


Name: ZZTEST, FCR FIVE THOUSAND
MRN: 88/000-00-0001
Date: 2001.01.11
Time: 13:57:00
1
3
B
1
3
A
Series: 0
W/L: 84/530

"A", "B", "1", and "3" are markers for orientation only.

Image of UAB Test Tool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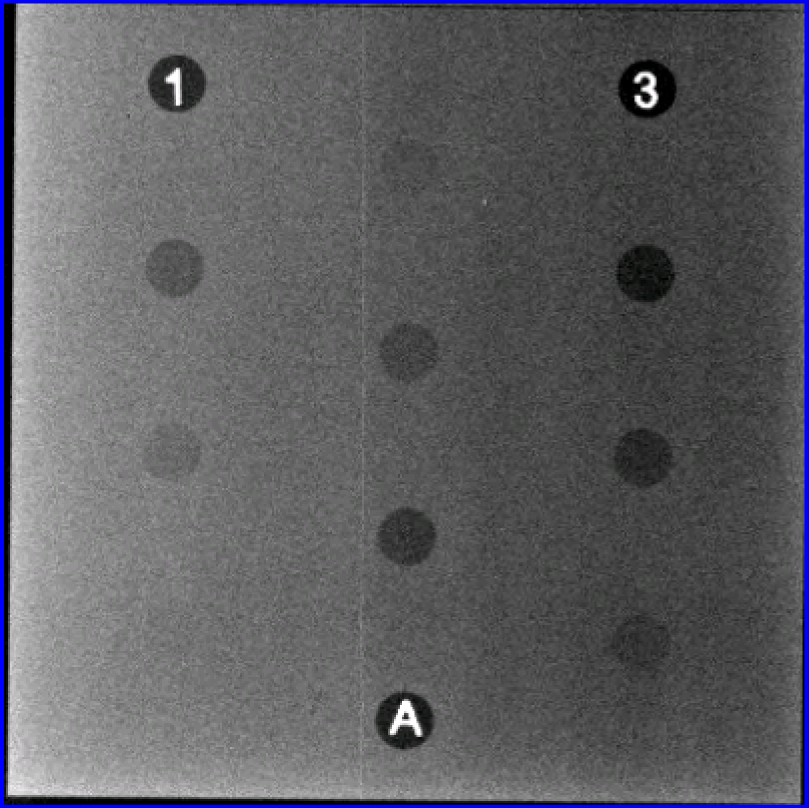
MRN: 88/000-00-0001
Date: 2001.01.11
Time: 13:57:00
1
3
B
1
3
A
Series: 0
W/L: 84/530

There are 9 holes of different depths on Plates A and B.

Image of UAB Test Tool

There are 9 holes of different depths on Plate A and on Plate B. Eight on each plate are clearly visible here.



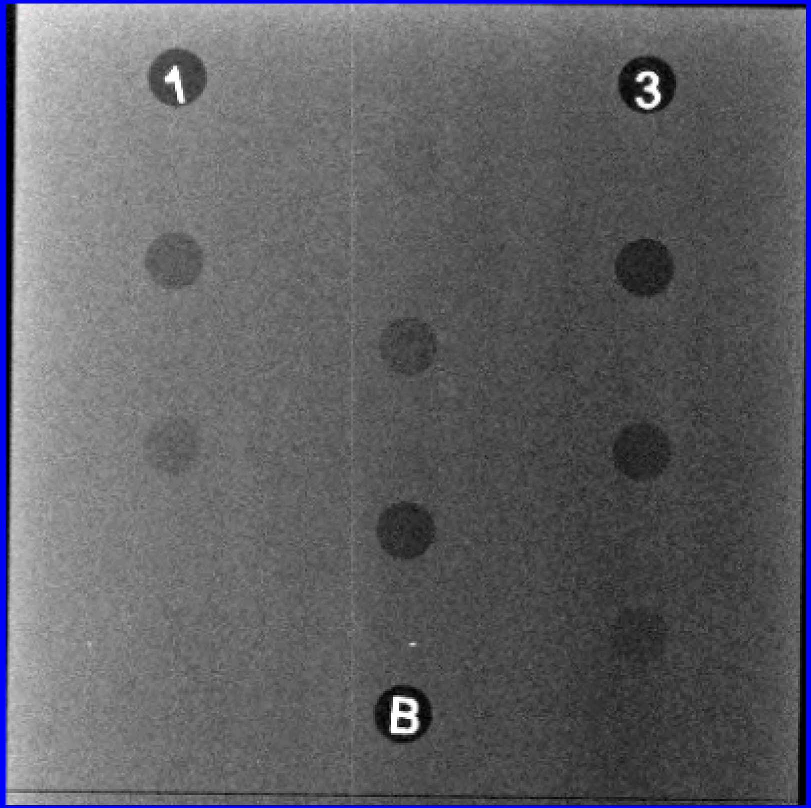
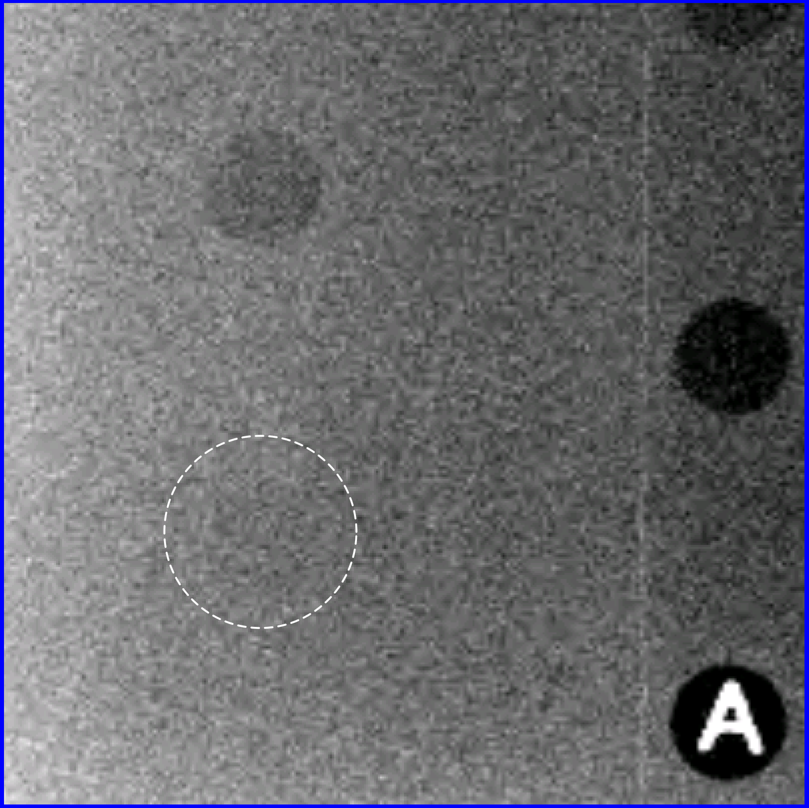
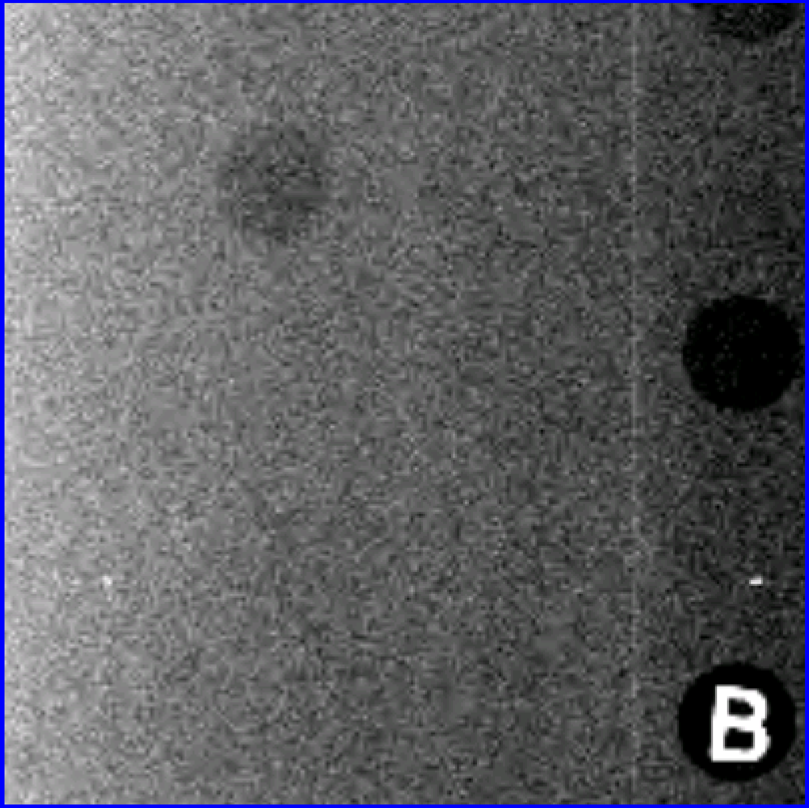


Image of UAB Test Tool

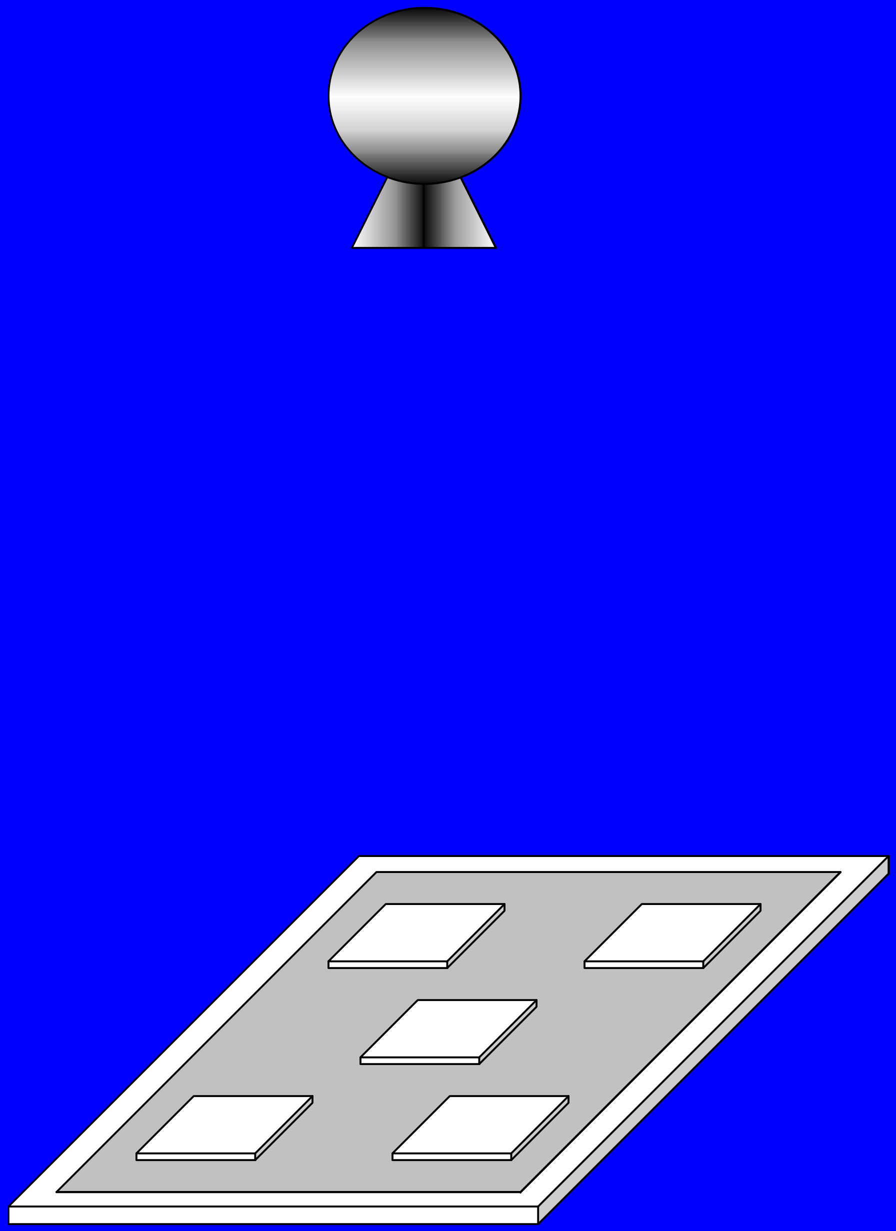
The dashed circle is the location of the 9th hole on each plate. Is either one visible?

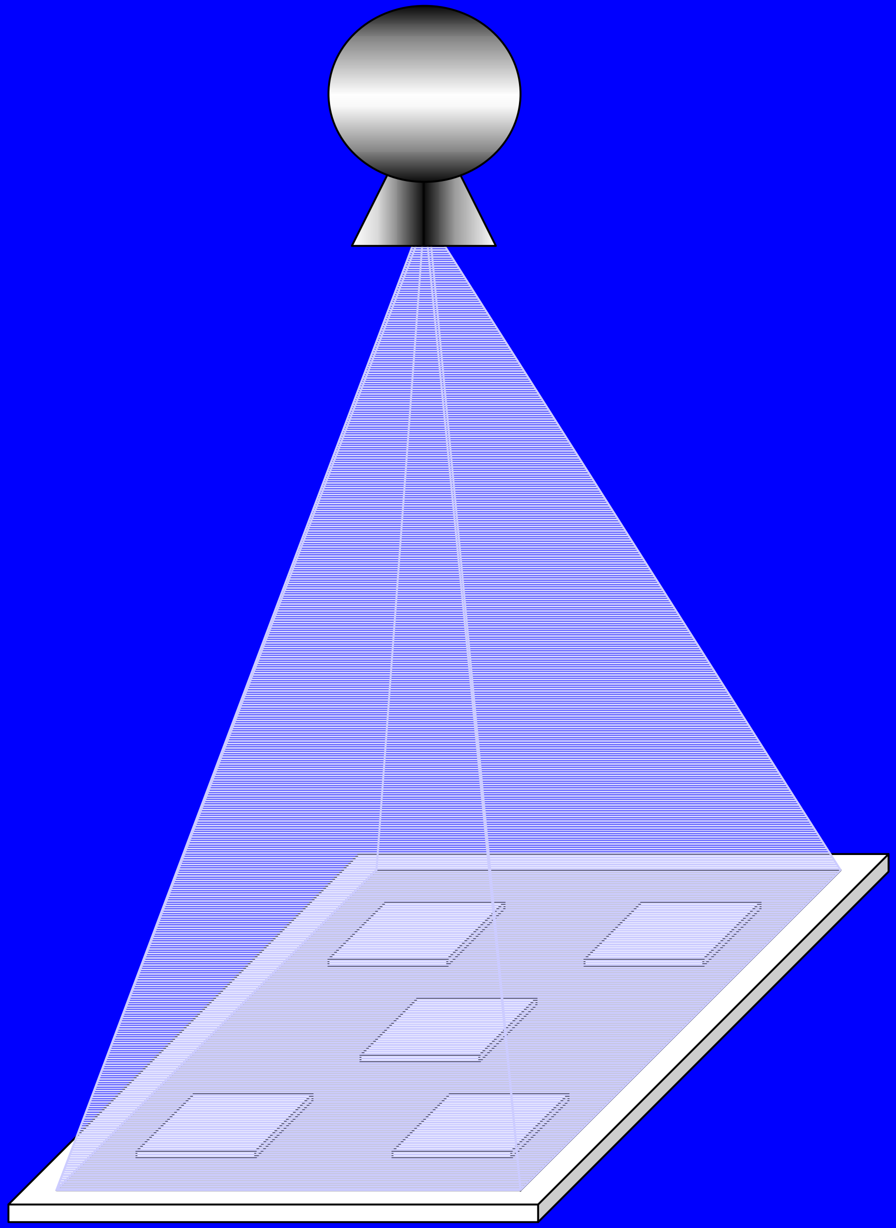


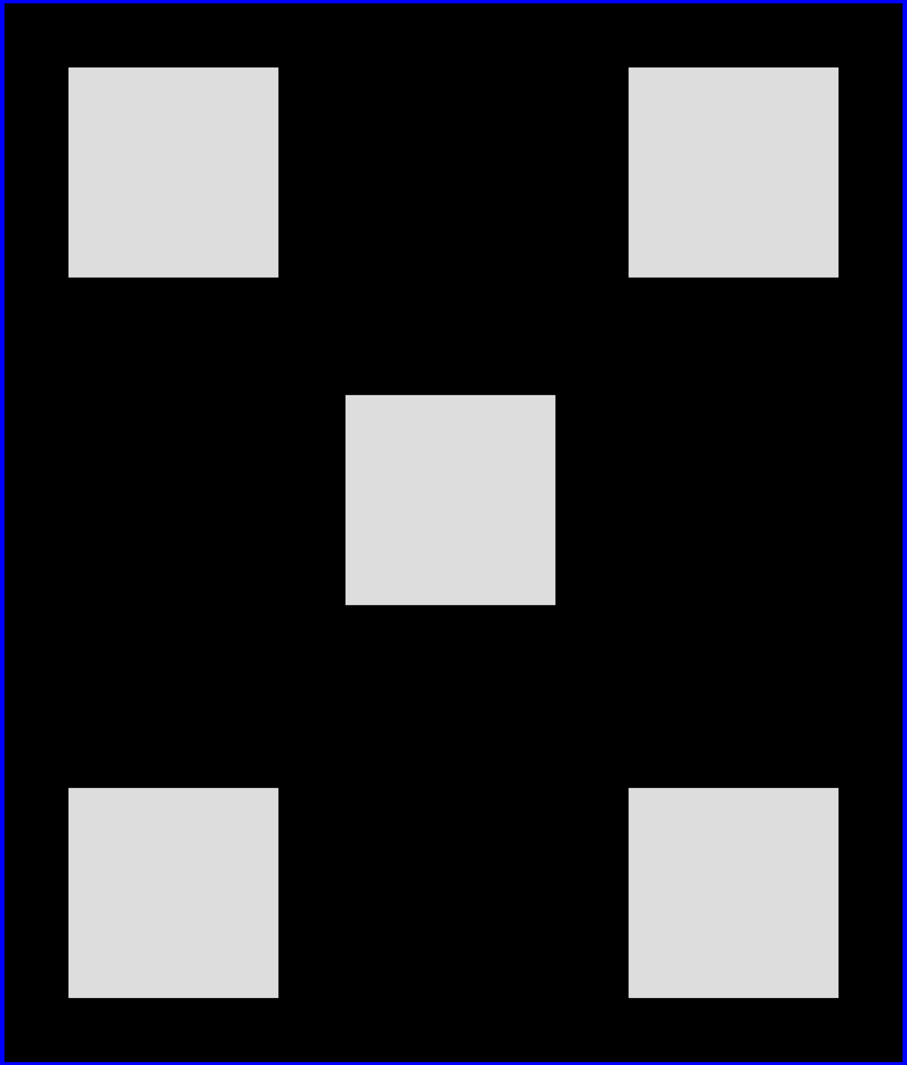


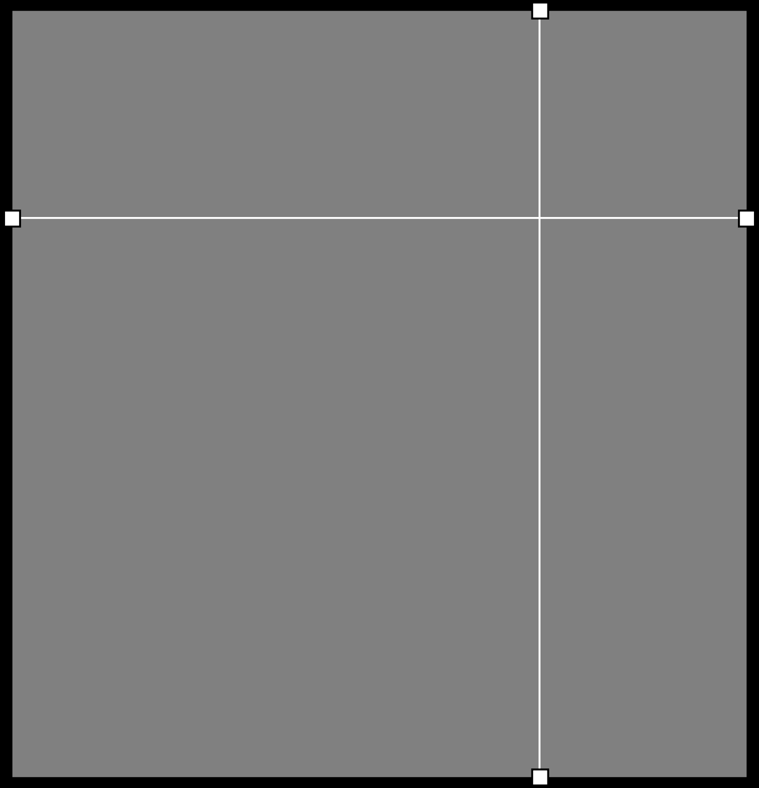
Distance Accuracy

- Image 100-mm square copper sheets at the center and each corner of one of each size cassette in common use.
  - edges parallel with the edges of the image receptor
  - expose the cassette to 1 mR (80 kVp, 180 cm SID)
- View test pattern on the image display workstation
  - measure the length and width of each square using the image display workstation distance tool
  - measurement should be (100 ± 2) mm



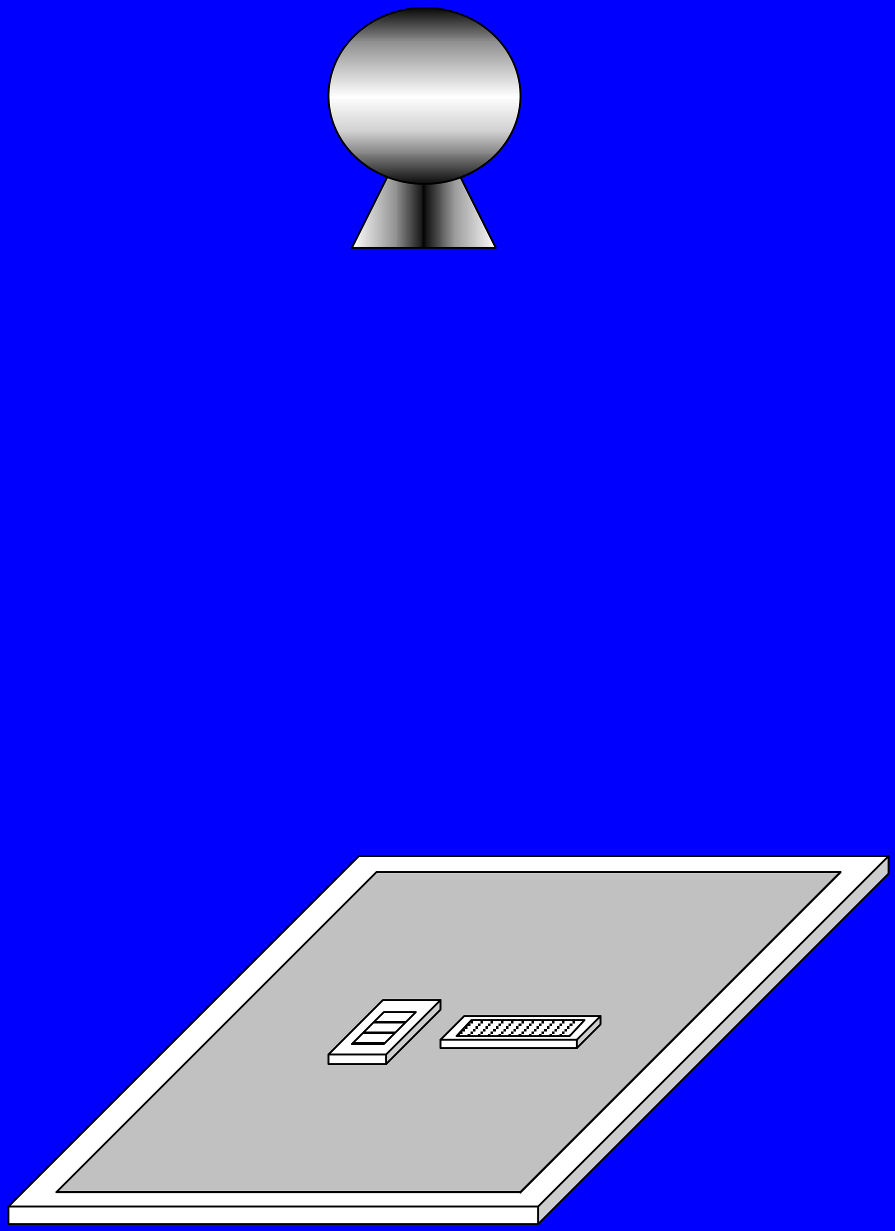


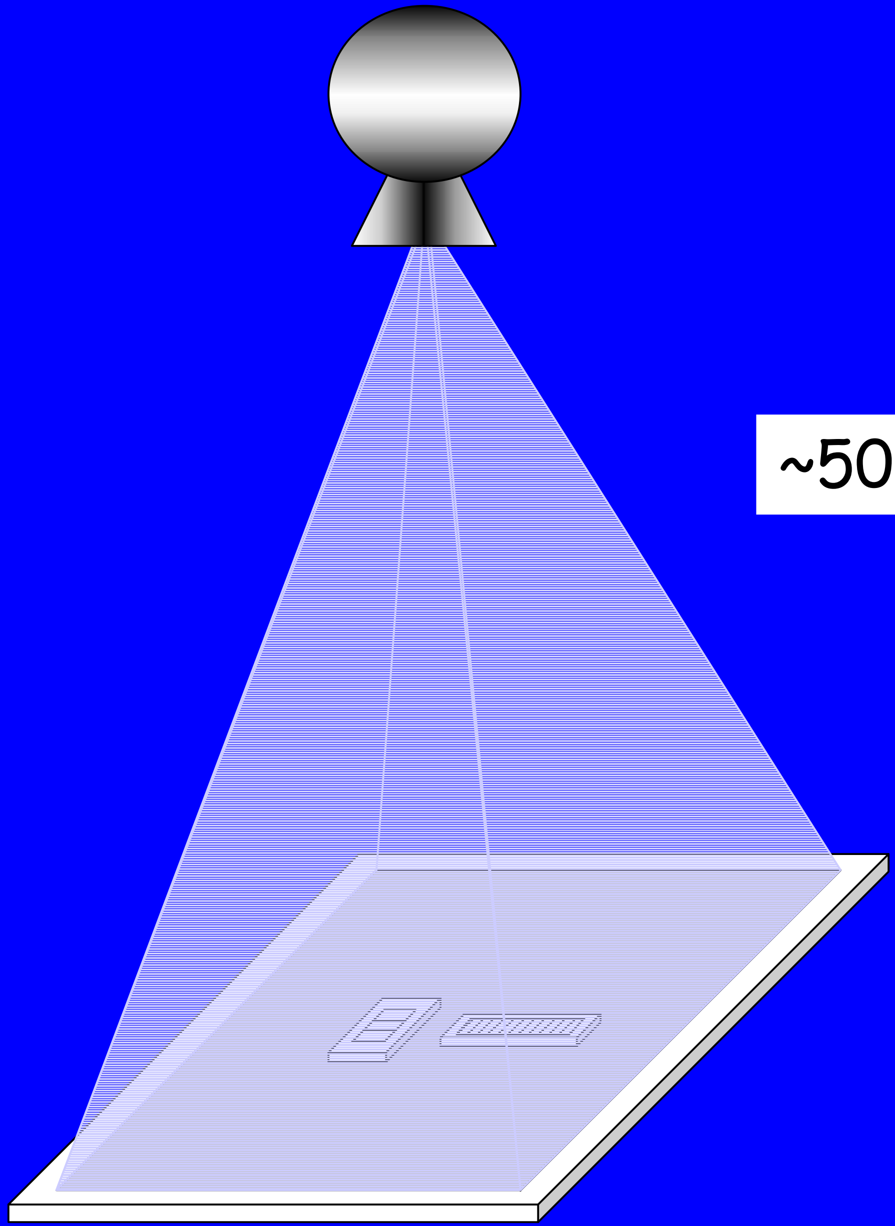




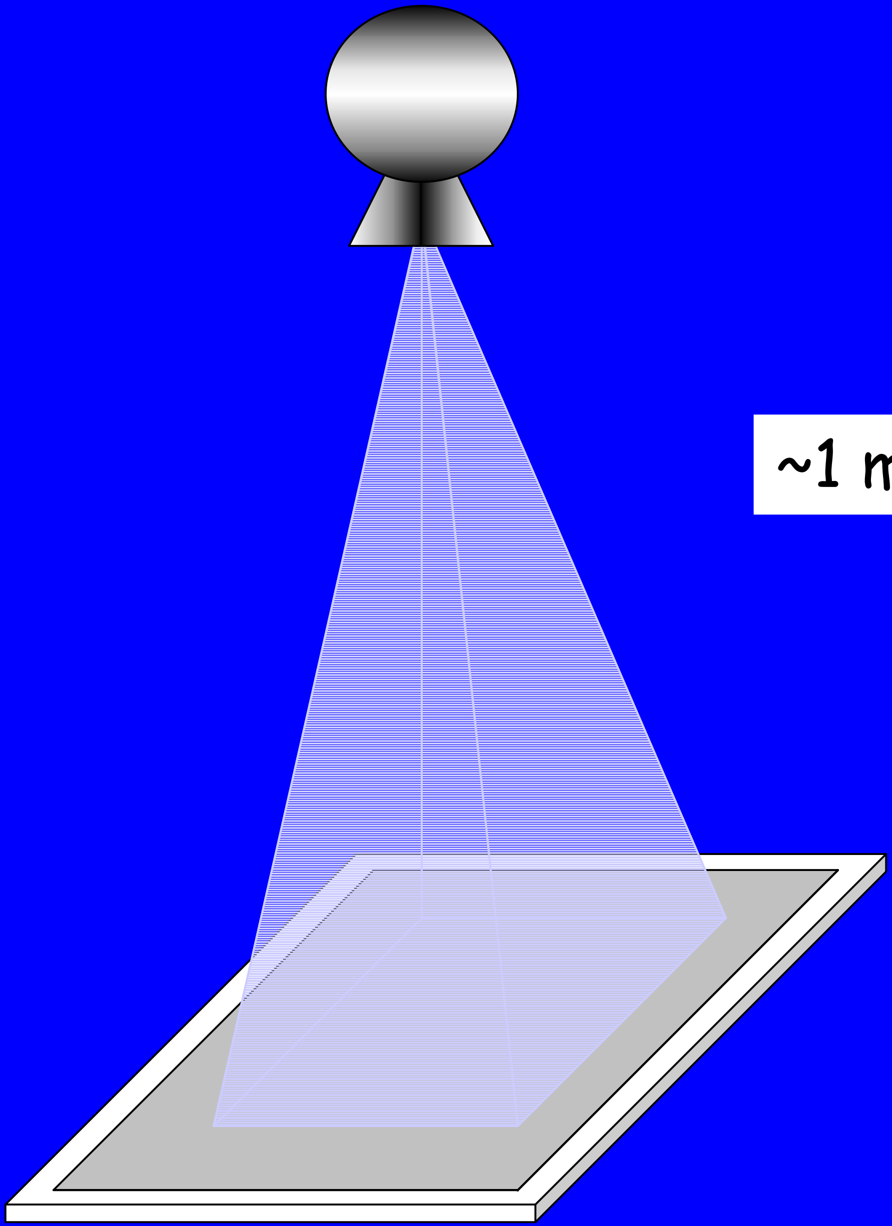
Accuracy/Thoroughness of Erasure Cycle

- Image a centrally placed resolution test pattern using any size IP/cassette
  - phantom in contact with cassette
  - expose to ~50 mR (80 kVp, 180 cm SID)
- Process the IP using a standard clinical algorithm.
- Immediately expose same IP to a uniform exposure of 1 mR.
  - use a slightly smaller collimated area
  - no test pattern used for this exposure
  - process using the same readout algorithm
- Examine the second image for the presence of residual ghost image from the first exposure.
  - No resolution test pattern should be detectable.





~50 mR



~1 mR

QC

W/L: 156/550

W/L: 156/550

Acceptance Testing and Quality Control of
Photostimulable Storage Phosphor Imaging Systems
Report of Task Group #10
American Association of Physicists in Medicine

Task Group #10 Members as of August, 1998: J. Anthony Seibert (Chair), Terri Bogucki, Ted Ciona, Jon Dugan, Walter Huda, Andrew Karellas, John Mercier, Ehsan Samei, Jeff Shepard, Brent Stewart, Orhan Suleiman, Doug Tucker, Robert A. Uzenoff, John Weiser, Chuck Willis

ABSTRACT

Photostimulable Storage Phosphor (PSP) imaging employs reusable imaging plates and associated hardware and software to acquire and display digital projection radiographs. This is a recent addition to diagnostic imaging technology. Procedures are needed to guide the diagnostic radiological physicist in the evaluation and continuous quality improvement of PSP imaging practice. This document includes overview material, generic functional specifications, testing methodology, and a bibliography. We describe generic, non-invasive tests that are applicable to a variety of PSP units. Manufacturers' appendices describe specifications, machine-specific attributes, and tests.

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15.5. Sample acceptance testing and quality control forms

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1. INTRODUCTION

The primary purpose of this document is to guide the clinical medical physicist in the acceptance testing of photostimulable storage phosphor (PSP) imaging systems. PSP imaging devices are known by a number of names including, *computed radiography* (CR), *storage phosphor imaging*, digital storage phosphor imaging, and digital luminescence radiography. In the digital form, PSP images are readily integrated into a Picture Archiving and Communications System (PACS). The tests we describe are appropriate for PSP systems in either integrated or stand-alone applications. Digital imaging technology is rapidly evolving: this represents the state of technology as of its writing. Proper application of this guide involves supplementing with current literature and specific manufacturer's technical data. A secondary purpose is to provide a consolidated source of information regarding device functionality, testing, and clinical practice of PSP imaging. This document provides the physicist with a means to conduct initial acceptance testing, interpret results, and establish baseline performance. A subset of these tests can be extended to routine quality control.

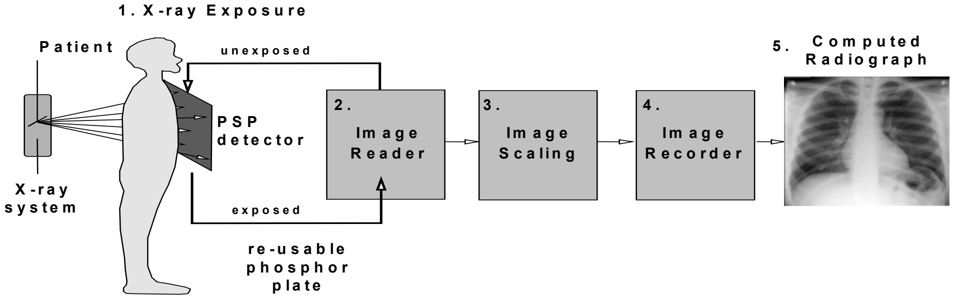
2. SYSTEM OVERVIEW

In order to test an imaging device, an understanding of its basic operating principles is necessary. The following text provides a basic discussion of those principles.

2.1 PSP Image acquisition

The ***photo-stimulable phosphor*** stores absorbed x-ray energy in crystal structure "traps", and is sometimes referred to as a "storage" phosphor. This trapped energy can be released if stimulated by additional light energy of the proper wavelength by the process of ***photostimulated luminescence*** (PSL). Acquisition and display of the PSP image can be considered in five generalized steps illustrated in Figure 1 below.

Figure 1.



The unexp o screen-
film imagi or by
absorption ›rocessed"
by placing ınd raster-
scanned w blue
photostimu r of x-ray
photons th r light,
channeled ınd stored in a digital image matrix. After the PSP detector is scanned, any residual latent image information is erased using an intense white light, and returned to service. Image analysis of the acquired raw digital data locates the pertinent areas of the useful image, and according to the user selected anatomical program transforms the subject contrast into a resultant grayscale image that mimics the appearance of analog film. Finally, the image is recorded on film or

viewed on an image monitor. In terms of acquisition, the PSP system closely emulates the conventional screen-film detector paradigm. There are, however, several important differences to understand and be aware of to take full advantage of PSP imaging capabilities.

2.2 PSP receptor characteristics

PSP devices are based on the principle of *photostimulated luminescence* [Takahashi, et al. 1983; Takahashi, 1984, deLeeuw et al, 1987, and vonSeggern, et al, 1988]. When a x-ray photon deposits energy in the PSP material, three different physical processes can account for energy conversion. *Fluorescence* is the prompt release of energy in the form of light. This process is the basis of conventional radiographic intensification screens. PSP imaging plates also emit fluorescence in sufficient quantity to expose conventional radiographic film [Chotas, 91, Mc Mahon 91]. This, however, is not the intended method of imaging. PSP materials store a significant fraction of the deposited energy in crystal structure defects, thus the name, *storage phosphors*. This stored energy constitutes the latent image. Over time, the latent image fades spontaneously by the process of *phosphorescence*. If stimulated to light of the proper wavelength, the process of stimulated luminescence can release a portion of the trapped energy immediately. The emitted light constitutes the signal for creating the digital image [Sonoda 83].

Many compounds possess the property of PSL [REF]. Few of these materials have characteristics desirable for radiography, i.e. a stimulation-absorption peak at a wavelength produced by common lasers, a stimulated emission peak readily absorbed by common photomultiplier tube input phosphors, and retention of the latent image without significant signal loss due to phosphorescence [Luckey, 1975]. The compounds that most closely meet these requirements are alkali-earth halides. Commercial products have been introduced based on RbCl, BaFBr:Eu^{2+}, BaF(BrI):Eu^{2+}, BaSrFBr:Eu^{2+}. A cross-section of the PSP receptor is illustrated in Figure 2. [Willis, in press]

Figure 2. Cross sectional views of the Fuji (left) and Kodak (right) PSP receptors are shown, indicating the various structures comprising the receptor and cassette holder. Note the differences existing between each manufacturer. Adapted from Willis[].

Doping and Absorption Process. Trace amounts of Eu^{2+}impurities are added the PSP to alter its structure and physical properties. The trace impurity, also called an *activator*, replaces the alkali earth in the crystal, forming a luminescence center. Ionization by absorption of x-rays (or UV radiation) forms electron/hole pairs in the PSP crystal. An electron/hole pair raises Eu^{2+} to an excited state, Eu^{3+}. Eu^{3+} produces visible light when it returns to the ground state, Eu^{2+}. Stored energy (in the form of trapped electrons) forms the latent image. There are currently two major theories for the PSP energy absorption process and subsequent formation of luminescence centers. These include a bimolecular recombination model [Takahashi 83], and a photostimulated luminescence complex (PSLC) model [vonSeggern, 87] shown in Figure 3. Physical processes occurring in BaFBr:Eu^{2+} using the latter model appears to closely approximate the experimental findings. In this model, the PSLC is a metastable complex at higher energy ("F-center") in close proximity to an Eu^{3+}-Eu^{2+} recombination center. X-rays absorbed in the PSP induce the formation of "holes" and "electrons", which activate an "inactive PSLC" by being captured by an F-center, or form an active PSLC by formation and/or recombination of "exitons" explained by "F-center physics" [vonSeggern, 87]. In either situation, the number of active PSLC's created (number of electrons trapped in the metastable site) are *proportional to the x-ray dose to the phosphor*.

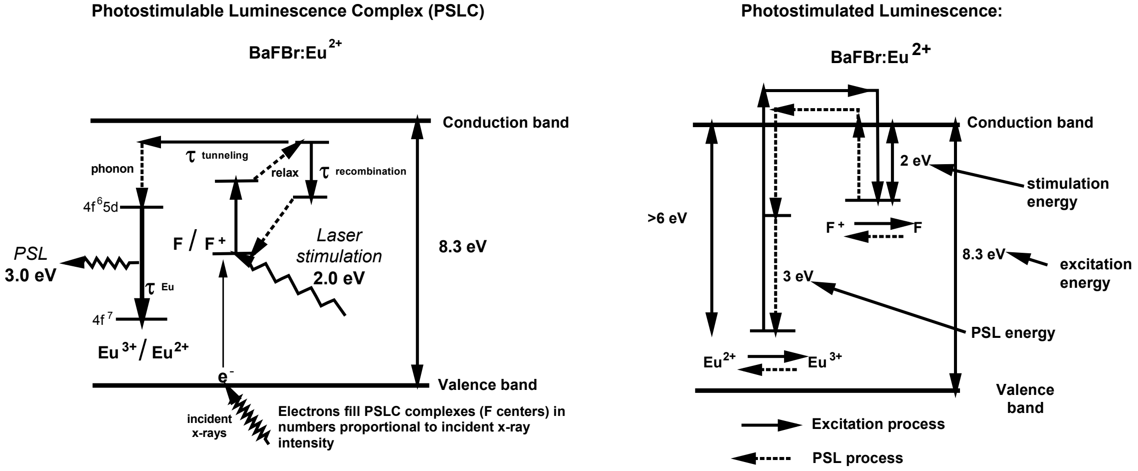

Photostimulable Luminescence Complex (PSLC)
BaFBr:Eu^{2+}
Conduction band
phonon
τ tunneling
relax
τ recombination
4f^{6}5d
F / F$^+$
Laser stimulation 2.0 eV
PSL 3.0 eV
τ Eu
8.3 eV
4f^7
Eu^{3+}/ Eu^{2+}
e$^-$
Valence band
incident x-rays
Electrons fill PSLC complexes (F centers) in numbers proportional to incident x-ray intensity
Photostimulated Luminescence:
BaFBr:Eu^{2+}
Conduction band
2 eV
stimulation energy
>6 eV
F$^+$
F
8.3 eV
excitation energy
3 eV
PSL energy
Eu^{2+}
Eu^{3+}
Valence band
Excitation process
PSL process

Figure 3. An energy diagram of the excitation and photo-stimulated luminescence processes in a BaFBr:Eu^{2+} phosphor. On the left is the representation of the interactions proposed by von Seggern, etal []. On the right is the proposed energy diagram of Takahashi, etal [] Incident x-rays form an "electron" latent image in a meta-stable "F" center site that can be processed with a low energy laser beam, producing the desired luminescent signals. τ is the decay constant of the indicated process above.

X-ray absorption efficiency of BaFBr:Eu is compared to Gd_2O_2S:Tb (rare-earth screens) for typical thicknesses of material encountered, as shown by attenuation curves illustrated in Figure 4. Between ~35 to ~50 keV, the BaFBr phosphor is actually a better x-ray attenuator due to the lower K-edge absorption of barium; however, below and above this range, the gadolinium rare-earth phosphor is superior. A typical beam spectrum incident on the PSP phosphor often requires greater exposure to achieve similar quantum statistics compared to a 400 speed rare-earth receptor. In addition, high absorption probability of x-rays below the k-edge of the PSP receptor, where a significant fraction of lower energy scattered x-ray distribution occurs, causes a greater sensitivity to scatter (thus reference to the PSP as a "scatter sponge" in this context).

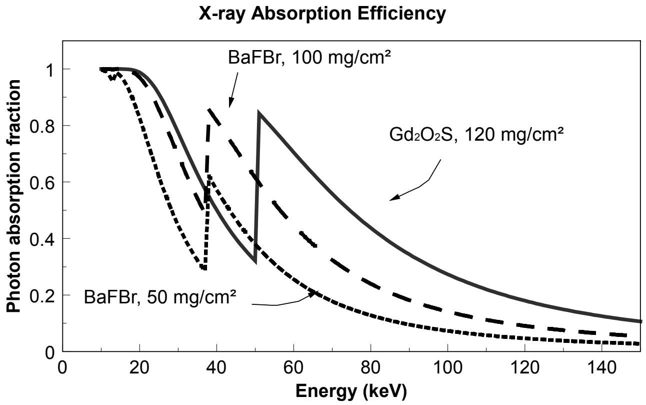
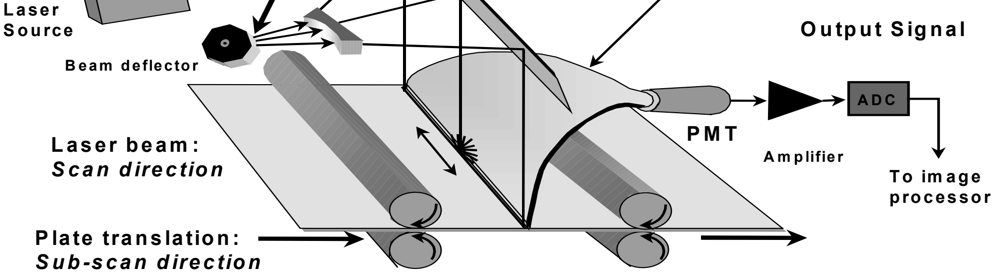


Figure 4. The photon absorption fraction of PSP and rare-earth x-ray phosphors are plotted as a function of energy. Phosphor thicknesses are representative of a standard 400 speed conventional screen, a "standard resolution" PSP phosphor detector (100 mg/cm^2), and a "high resolution" PSP phosphor detector (50 mg/cm^2).

Fading. Fading of the trapped signal will occur exponentially over time, through spontaneous *phosphorescence.* A typical imaging plate will lose about 25% of the stored signal between 10 minutes to 8 hours after an exposure, and more slowly afterwards [Kato, 94]. Fading introduces uncertainties in output signal that can be controlled by introducing a fixed delay between exposure and readout [ref??] to allow decay of the "prompt" phosphorescence of the stored signal.

Stimulation and Emission. The "electronic" latent image imprinted on the exposed BaFBr:Eu phosphor corresponds to the activated PLSC's (F-centers), whose local population of electrons is directly proportional to the incident x-ray flux for a wide range of exposures, typically exceeding 10,000 to 1 (four orders of exposure magnitude). Stimulation of the Eu^{3+}- F-center complex and release of the stored electrons requires a minimum energy of ~2eV, most easily deposited by a highly focused laser light source of a given wavelength. Lasers produced by HeNe (λ=633 nm) and "diode" ($\lambda \cong$680 nm) sources are most often used. The incident laser energy excites electrons in the local F-center sites of the phosphor. According to von Seggern [vonSeggern, 87], two subsequent energy pathways within the phosphor matrix are possible—to return to the F-center site without escape, or to "tunnel" to an adjacent Eu^{3+} complex. The latter event is more probable, where the electron cascades to an intermediate energy state with the release of a non-light emitting "phonon". A light photon of 3 eV energy immediately follows as the electron continues to drop through the electron orbitals of the Eu^{3+} complex to the more stable Eu^{2+} energy level. Figure 5 shows a plot of the energy spectra of the laser-induced electron stimulation and subsequent light emission. Different phosphor formulations have optimal stimulation energies tuned to specific laser energy. For best imaging performance, it is best to use the phosphors designed for a particular PSP reader system.



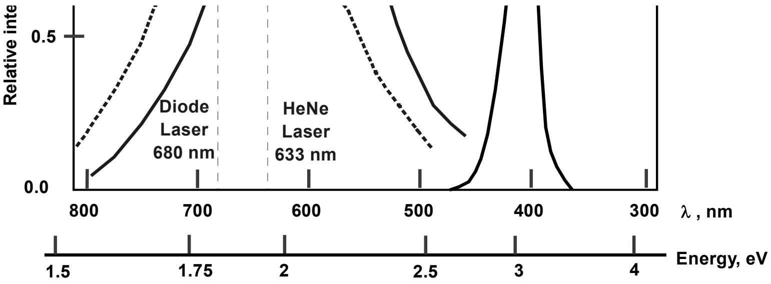


Figure 5. Stimulation and emission spectra for BaFBr:Eu $^{2+}$ and $BaFBr_{0.85}I_{0.15}$:Eu $^{2+}$ storage phosphors demonstrate the energy sensitivity of different phosphor formulations and the energy separation of the excitation and emission events. Selective optical filtration isolates the light emission intensity from the incident laser intensity. In absolute terms, intensity of the emitted light is significantly lower. (Figure adapted from reference [[vonSeggern, 87]])

2.3 The readout process

Laser Scanning. Produced by either a HeNe or diode laser source, the laser beam is routed through several optical components prior to scanning the phosphor plate. First, a beam splitter uses a portion of the laser output to monitor and compensate for intensity fluctuations through the use of a reference detector. This is important, as the intensity of the stimulated light is dependent on the power of the stimulating laser [Bogucki, 95]. The major portion of the laser energy reflects off scanning mirror (rotating polygonal or oscillating flat reflector), through an optical filter, shutter, and lens assembly, providing a synchronized scanning beam. To maintain a constant focus and linear sweeping velocity across the PSP plate, the beam passes through an f-θ lens to a stationary mirror (typically a cylindrical and flat mirror combination). The laser spot distribution on the phosphor is adjusted to have a gaussian profile with a $1/e^2$ diameter of approximately 100 µm in most reader systems. Basic system architecture of the PSP reader components is illustrated in Figure 6.

Figure 6. Major components of a PSP reader include the stimulating laser source, a beam splitter, oscillating beam deflector, f-θ lens, cylindrical reflecting mirror, light collection guide, and photomultiplier tube (PMT). The plate is translated in a continuous motion through the laser beam scan by pinch rollers. All component functions are orchestrated by digital computer. In some readers, multiple PMT's are used for capturing the signal.

The speed of the laser beam across the phosphor plate is adjusted according to the luminescent signal decay time constant (~0.8 µs for BaFBr:Eu^{2+}) following excitation, which is the major factor limiting the readout time. Laser beam power determines the fraction of the stored energy released, and impacts the scan time, phosphorescent lag effects, and residual signal. Higher laser power can release more of the trapped electrons, but the tradeoff is a loss of spatial resolution caused by increased depth of the laser beam and increased spread of the stimulated light in the phosphor layer.

At the end of the scanned line, the laser beam is retraced to the start. Since the phosphor screen is simultaneously moving, the translation speed is adjusted such that the next sweep of the laser beam initiates another scan line with spacing equal to the effective sampling pitch along the fast sweep direction. This ensures that sample dimensions are equal in the x and y directions. Scanning and translation of the plate continues in a raster fashion over the total phosphor area. S*can direction, laser scan direction,* or *fast-scan direction* is the terminology that refers to the direction along the path of the laser beam deflection. *low scan, plate scan, or sub-scan direction* refers to the phosphor plate travel direction. Phosphor plate translation speed is selected for a given-sized plate in order to advance the plate incrementally with a single pass of the laser so that the effective sample size is equal in the scan and sub-scan dimensions. The $1/e^2$ diameter of the laser spot at the surface of the imaging receptor is fixed in all present commercial systems, and imposes an upper limit to spatial resolution in both dimensions [REF]. The intensity of PSL as the laser passes across the plate is proportional to the x-ray energy absorbed by that area. Characteristics of the plate readout geometry are shown in Figure 7.

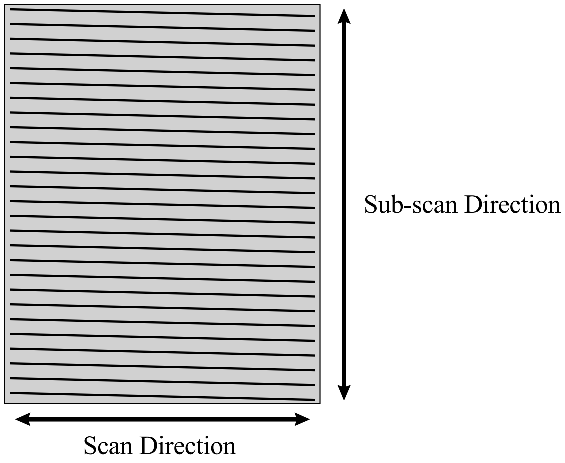


Figure 7. A diagram of the raster-scan of the phosphor detector indicates the fast scan (laser scan) direction and the sub-scan (plate scan) direction. Note the slightly skewed angle of the readout lines relative to the edge of the phosphor plate, due to the simultaneous laser beam scanning and linear plate translation.

Residual latent image signals are contained on the phosphor plate after readout. Erasure of the plate using a high intensity light source is accomplished prior to return to the inventory. Unless an extreme overexposure occurs, essentially all of the residual trapped electrons are effectively removed during the erase cycle. On some systems, the erasure of the plate is a function of the overall exposure, whereby longer exposures require a longer erasure cycle. A summary of the PSP receptor cycle is illustrated in Figure 8.

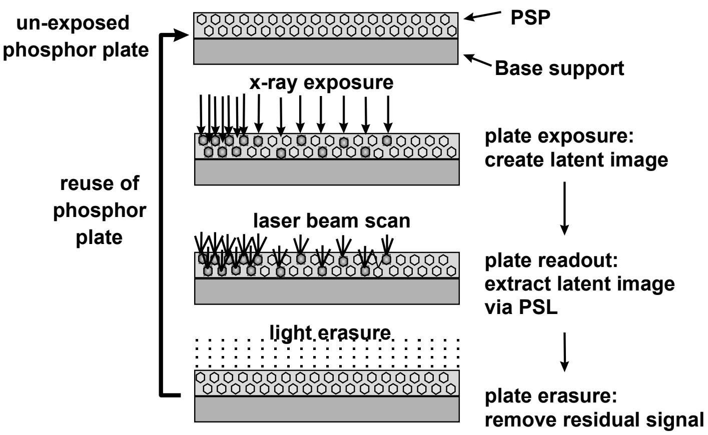

un-exposed phosphor plate
PSP
Base support
x-ray exposure
plate exposure: create latent image
reuse of phosphor plate
laser beam scan
plate readout: extract latent image via PSL
light erasure
plate erasure: remove residual signal

Figure 8. The phosphor plate cycle is depicted above. An unexposed plate is comprised of the PSP material layered on a base support and protected by a thin, transparent coating. Exposure to x-rays creates latent image centers of electrons semi-stable energy traps in the crystal structure. Latent image processing is accomplished with a raster-scanned low power laser beam (e.g., 20-milliwatt HeNe laser @633 nm). Trapped electrons are released from the luminescent centers and produce light that is collected by a light guide assembly and directed to a photomultiplier tube. Residual trapped electrons are removed with a high intensity light source, and the plate is returned to the inventory for reuse.

Detection and conversion of the PSL signal. PSL is emitted in all directions from the phosphor screen. An optical collection system (mirror cavity or acrylic light collecting guide positioned at the laser – phosphor interface along the scan direction) captures a portion of the emitted light, and channels it to the photocathode of the PMT (or PMTs) of the reader assembly. Detection sensitivity of the photocathode material is matched to the wavelength of the PSL (e.g., ~400 nm). Photoelectrons emitted from the photocathode are accelerated and amplified through a series of dynodes within the PMT. Gain (and thus detector speed) is varied by adjustment of the voltage placed on the dynodes, so that a useful output current is obtained for a given (clinical) exposure for proper image quality. Dynamic range of the PMT output signal is much greater than that of the phosphor plate, allowing high signal gain over a wide range of exposures. Light intensity variations correspond to incident radiation exposure variations linearly over a range of 1-10,000 or “four orders of magnitude”. Digitization of the output signal requires the identification of a minimum and maximum signal range, since most clinically relevant transmitted exposure variations occur over a dynamic range of 100-400. In some PSP readers, a low energy laser pre-scan coarsely samples the exposed PSP receptor and determines the useful exposure range. The gain of the PMT is then adjusted (increased or decreased) to digitize the PSL during the high-energy laser scan. In most systems, the PMT amplifier is pre-adjusted to be sensitive to the PSL resulting from an exposure range corresponding over a range of 2.58×10^{-9} C/kg (0.01 mR) to 2.58×10^{-5} C/kg (100 mR).

Most PSP reader systems then amplify the PMT output signal with an analog logarithmic amplifier or a “square root” amplifier. Logarithmic conversion provides a linear relationship of incident exposure to output signal amplitude; square-root amplification provides a linear relationship with the quantum noise associated with the exposure. In either case, the total dynamic range of signal is compressed to preserve digitization accuracy over a limited number of discrete gray levels.

Digitization. Digitization is a two step process of converting an analog signal into a discrete digital value. The signal must be *sampled* and *quantized*. Sampling determines the location and size of the PSL signal from a specific area of the PSP receptor, and quantizing determines the average value of the signal amplitude within the sample area. The output of the PMT is measured at a specific temporal frequency coordinated with the laser scan rate, and quantized to a discrete integer value dependent on the amplitude of the signal and the total number of possible digital values. An Analog to Digital Converter (ADC) converts the PMT signals at a rate much faster than the fast scan rate of the laser (on the order of 2000 times faster, corresponding to the number of pixels in the scan direction). A pixel clock coordinates the time at which a particular signal is encoded to a physical position on the scan line. Therefore, the ratio between the ADC sampling rate and the fast scan (line) rate determines the pixel dimension in the scan direction. The translation speed of the phosphor plate in the sub-scan direction coordinates with the fast scan pixel dimension so that the width of the line is equal to the length of the pixel (i.e., the pixels are "square"). The pixel size is typically between 100 and 200 μm, dependent on the dimensions of the receptor.

Although the analog output from the PMT has an infinite range of possible values between a minimum and maximum voltage, the ADC breaks the signal into a series of discrete integer values (analog to digital units) for encoding of the signal amplitude. The number of bits used to approximate the analog signal, or "pixel depth" determines the number of integer values. PSP systems typically have 10, 12 or 16 bit ADCs, so there are $2^{10} = 1024$, to $2^{12}= 4096$, to $2^{16}=65536$ possible values for a given analog signal amplitude. One manufacturer (Kodak) uses a 16-bit digitization to implement a *digital* logarithmic transformation to the final 12-bit/pixel image. Other system manufacturers use an *analog* logarithmic amplifier (Fuji) or a square-root amplifier (Agfa) on the *pre-digitized* signal. Analog amplification avoids quantization errors in the signal estimate when the number of ADC bits (quantization levels) is limited [Seibert, 95].

2.4 Characteristic Curve Response

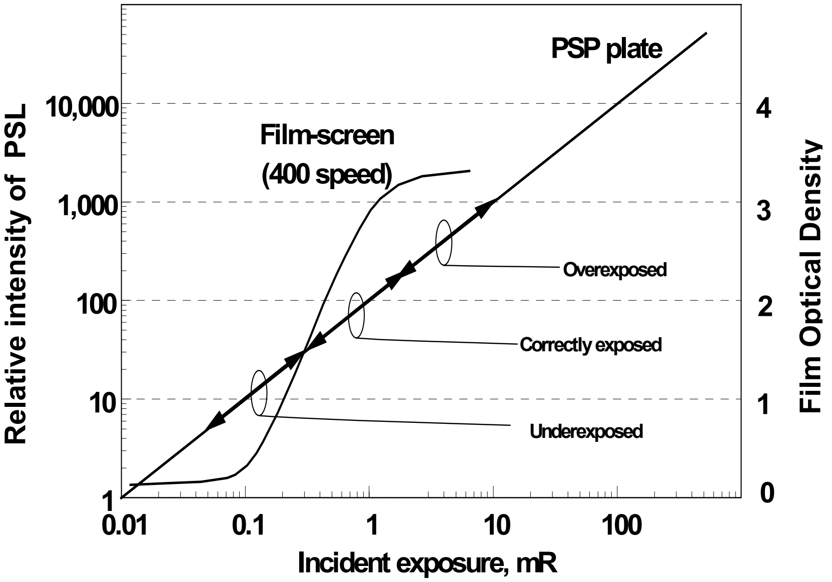


Figure 9. The characteristic curve of rare-earth screen-film (400 speed) and the PSP receptor are compared. Exposure ranges superimposed on the PSP curve roughly indicate the exposure range for screen film response of a 200 speed system.

Figure 9 illustrates the characteristic curve response of a typical PSP receptor to a 400-speed screen-film system. A linear, wide latitude response to variations in incident exposure is characteristic of the phosphor plate, while film is optimally sensitive to a restricted range of exposures. For screen-film detectors, which serve as both the acquisition *and* display medium, it is necessary to tune the detector (film) contrast and radiographic speed to a narrow exposure range to achieve images with optimal contrast and minimal noise characteristics. PSP receptors are not constrained by the same requirements because the acquisition and display events occur separately so that compensation for under- and over-exposures is possible by the algorithms applied to the digital data. However, identification of useful signal range must be accomplished prior to the auto-ranging and contrast enhancement of the output image. In addition, since under- or overexposed images can be "masked" by the system, a method to track exposures on an image by image basis is necessary to recognize those situations that exceed the "proper" exposure range so that appropriate action can be taken to resolve any problems.

3. PROCESSING THE RAW PSP IMAGE

3.1 Readout Parameters

Wanted vs. Unwanted Image Signals. In conventional screen-film radiography, the x-ray technologist adjusts the exposure technique to put the desired range of image signals on the linear portion of the H&D curve. The image signals from x-rays outside of the object yet on the detector fall into the shoulder (high exposure range) of the curve, and the image signals beyond the edges of the collimators fall into the toe (low exposure range). The PSP system must similarly encode the useful image signal, to provide maximum contrast sensitivity through look-up-table adjustments of the digital values. Just as the radiographic technique and the image receptor are selected for the specific anatomic view, the PSP readout algorithms make adjustments to the digital image specific to the anatomy.

Partitioned pattern and exposure field recognition. The first task for some PSP systems is to determine the number and orientation of views in the raw digital data on the exposed receptor. Each view can then be analyzed independently. While multiple views on a single cassette are good practice in conventional radiography, it can be a possible complication for PSP radiography. Within an exposure field, it is important for the PSP reader to distinguish the useful region of the image by locating the edges of collimation. Some PSP systems further segment the image by defining of the edges of the anatomic region. Once the useful image is correctly located, the PSP system can disregard the image information beyond the collimator boundaries when performing further analysis.

Histogram analysis. The method for determining the "useful signal" range for most PSP systems requires the construction of a *gray-scale histogram* of the image, a graph of pixel value on the x-axis and frequency of

occurrence on the y-axis (i.e., a spectrum of pixel values). Figure 10 shows an example of statistically noise-free histograms.

Figure 10. A simple example of image histograms depicts the outcome of an unexposed, uniformly exposed, and linearly exposed PSP receptor without any additive quantum or other noise sources.

The general shape of a histogram is dependent on the anatomy and the radiographic techniques employed for the image acquisition. All PSP readers employ an analysis algorithm to identify and classify the components of the histogram that correspond to bone, soft tissue, skin, contrast media, collimation, unattenuated x-rays and other signals. This allows the discrimination of the useful and unimportant areas of the image so that the image grayscale range can be properly rendered. An example of a chest-specific histogram is shown in Figure 11.

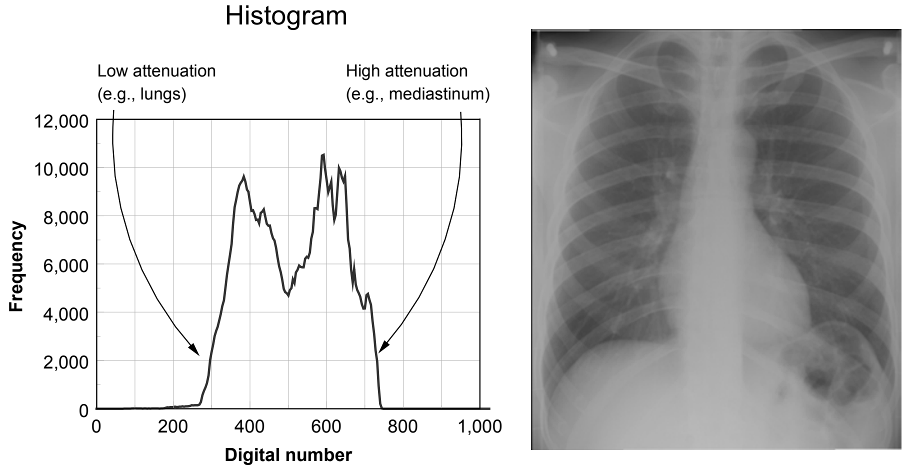


Figure 11. A chest histogram illustrates the various components of the frequency distribution of pixel values within the active area of the image, corresponding to anatomical variations. In this example, the digital values are directly related to the attenuation, similar to a screen-film image, by using a reverse look-up-table that inverts the digital representation of the PSL.

The result of histogram analysis allows the normalization of raw image data for standard conditions of speed, contrast, and latitude determined by the digital number analysis. Rescaling and contrast enhancements are optimized to render the appropriate image grayscale characteristics for the specific patient examination. Each manufacturer implements a specific method for this remapping procedure. With some systems, the latent image information is identified and re-sampled to a smaller range of digital values to minimize quantization errors. Any errors in identification of the exposure range can be irreversible and require re-acquisition of the image. Other systems digitize the full dynamic range of the PSL signal and then apply remapping algorithms to the digital data. In either case, the pertinent image information on the phosphor plate must be identified for subsequent grayscale and/or frequency processing, as the shape and information content of the histogram affects the processing of the image. An example of identifying and linearly amplifying the image signal, also known as *autoranging*, is described in Figure 12 for two exposure scenarios (typical of the processing by Fuji PSP systems). In each case, the proper output range of digital values is obtained.

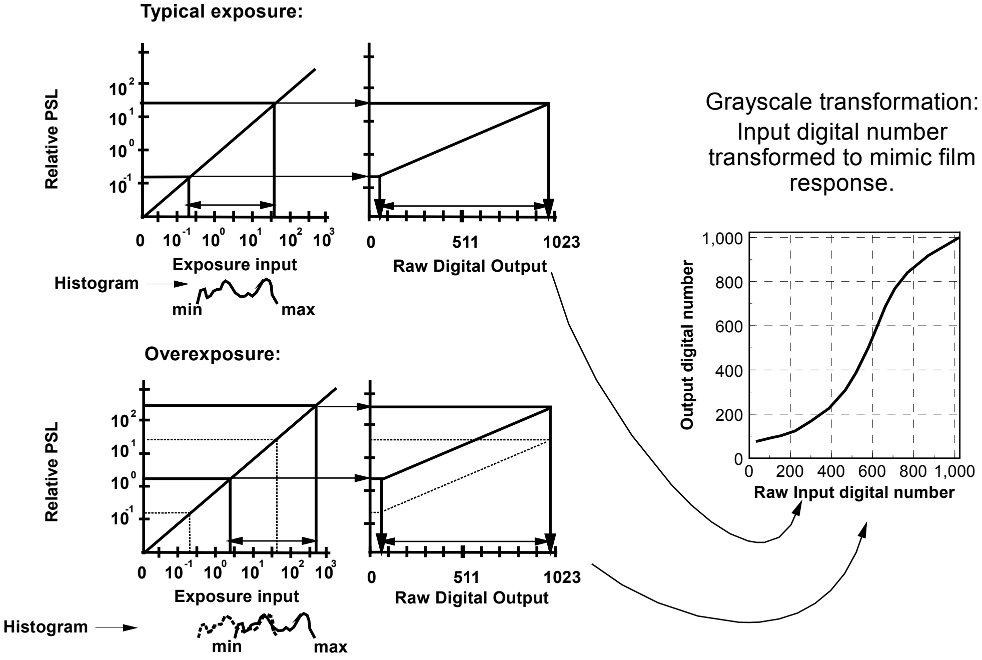

Typical exposure:
Relative PSL
10^2
10^1
10^0
10^{-1}
0 10^{-1} 10^0 10^1 10^2 10^3
Exposure input
0 511 1023
Raw Digital Output
Histogram
min
max
Overexposure:
Relative PSL
Exposure input
Raw Digital Output
Grayscale transformation:
Input digital number transformed to mimic film response.
Output digital number
1,000
800
600
400
200
0
0 200 400 600 800 1,000
Raw Input digital number

Figure 12. Autoranging of incident exposure into a corresponding digital number range is accomplished by analyzing the image histogram. (A) Minimum and maximum values of the histogram are “mapped” to minimum and maximum digital values (10 bit range in this case.) (B) Overexposure results in higher PSL signals that shift the histogram distribution to a higher digital number range, but the system compensates by adjusting the amplitude gain (digital or analog) to compensate. A grayscale transformation of the linear signals into a non-linear relationship by a digital transformation table occurs as depicted on the right hand side of the figure. Often a reverse look-up-table is used so that the output image mimics a film image, such that high digital numbers represent high attenuation, as in figure 11.

3.2 Image grayscale processing.

PSP images are matrices of digital pixel values that are readily manipulated to produce alternative image presentations. Three broad categories of processing include image contrast variation, spatial frequency content modification, or special image algorithm implementation.

PSP systems manufacturers provide sophisticated computer hardware and software to process images. Some OEMs and third party vendors provide similar functionality for remote processing of image data. No comprehensive source of information about manufacture***r*** specific algorithms and implementation exists. This is due in part to the immature nature of the PSP marketplace and digital image processing in the practice of radiology. Significant misunderstanding exists, both inside and outside the manufacturer community, about the proper use of image processing software. Selection and optimization of processing parameters is a non-trivial task that potentially requires “many thousands of man-hours by highly skilled staff” [Vuylsteke, Dewaele, and Schoeters “Optimizing Computed Radiography Imaging Performance” 1997 AAPM Summer School 107-152]. A common problem is that the range of processing parameters far exceeds clinically useful values and ***can*** lead to gross over-processing artifacts. Modification of processing parameters should not be undertaken ***casually.***

Contrast Processing. Because of small differences in attenuation of the human body, the PSP data has very little inherent contrast. To increase the visibility of anatomic detail, manufacturers provide *contrast-processing* software. The purpose of contrast processing is to create an image data set with contrast similar to conventional screen-film images, or to enhance the conspicuity of desirable features. This type of processing is also referred to as *Gradation Processing*, *Tone Scaling* and *Contrast Enhancement* by various vendors.

There are two different methods implemented for contrast processing. The most common technique employs remapping individual pixel values according to user controlled look-up tables (LUTs). ***All three manufacturers employ*** this technique, ***a global modification of the contrast curve that can produce different local contrast from identical features at different grayscale levels.*** Fuji uses four different parameters (GA, GC, GT and GS) to control this processing [Gingold 94 paper on factors], Kodak uses two (average density and LUT start) [Kodak/Bogucki], ***and AGFA uses three (Extend window left, Extend window right, and Sensitometry).*** The Fuji processing provides selection of the basic curve shape (GT) that mimic commercially available screen-film systems, the ability to increase or decrease gradient (GC and GA), and overall brightness (GS). Kodak provides for the selection of one of several pre-defined LUTs. ***AGFA provides four pre-defined display functions (Sensitometry). Mapping of gray-scale data to the display function is controlled by adjusting the display window derived from the gray-scale histogram (Extend window left, Extend window right).***

A second type of contrast processing, ***implemented by Fuji and AGFA, modifies contrast by performing operations on filtered versions of the original image and reconstructing a modified version of the original. Fuji's Dynamic range control (DRC) begins by creating a blurred version of image from the original. A weighting function that can be positive or negative is applied to the blurred image. The weighted version of the blurred image is added back into the original to*** enhance contrast ***either*** in low signal regions (mediastinum and sub-diaphragm) or high signal regions (air contrast, skin margins) [Kobayashi, SPIE paper, early 1990s***/. (Note: DeJarnette Research showed combined toe and shoulder DRC at SCAR98)***. DRC processing is optional, and ***is*** controlled by three user-selectable ***parameters for each anatomical menu selection: the kernel size, curve type and boost factor. AGFA's global contrast enhancement is an integral part of*** MUlti Scale Image Contrast Amplification (MUSICA®)***. MUSICA® decomposes*** the image ***into*** a set of coefficients corresponding to image features ***in twelve specific frequency sub-bands***. ***The*** image is decomposed according to ***a*** Laplacian pyramid transform [Burt PJ, Adelson EH: The Laplacian pyramid as a compact image code. IEEE Trans on Comm 1983; 31(4):532-540]. ***During acquisition, rather than via histogram analysis described above, both global contrast enhancement and normalization are accomplished by automatic modification of*** the coefficients of ***sub-bands of the*** Laplacian pyramid. ***The extent of contrast enhancement in both high and low signal regions is controlled by Latitude Reduction, a MUSICA® processing parameter that attenuates the low frequency sub-bands.***

Frequency Processing. One purpose of digital image processing is to enhance the conspicuity of features within the data. *Frequency processing* enhances features within the image that can be characterized by their specific spatial frequency. Several techniques exist in the literature to accomplish this goal, including Fourier filters [] and blurred-mask subtraction [], and wavelet filtering []. Early users of PSP systems routinely printed each image twice on a single film using different presentations, one presentation designed to mimic the appearance of a conventional screen-film combination, the other with significant amounts of "edge-enhancement." This practice is not routinely followed in the U.S. because of user preference for larger image size and a more traditional appearance of the image.

Both Fuji and Kodak implement blurred-mask subtraction techniques []. In this technique, the original image is blurred by convolution with a uniform kernel of a selected size. The blurred image is then subtracted from the original image, resulting in an image contains predominantly high frequency information. Multiplying each pixel by a user-defined enhancement factor modulates the high frequency information. Adding the resultant image to the original image and normalizing the data set creates the frequency-enhanced image. User selectable parameters include kernel size (*RN* for Fuji, mask size for Kodak), and enhancement factors (*RE* for Fuji, *boost* for Kodak). In addition, both manufacturers provide the capability of spatially localizing enhancement base on gray-scale value in the original image. The *RT* parameter specifies a function whose input is pixel value and output ranges from 0 to 1. The output of the function is multiplied by the *RE* value to determine the final amount of pixel enhancement. Likewise, Kodak provides for the selection of density localized *boost* functions. Figure __ summarizes the enhancement technique.

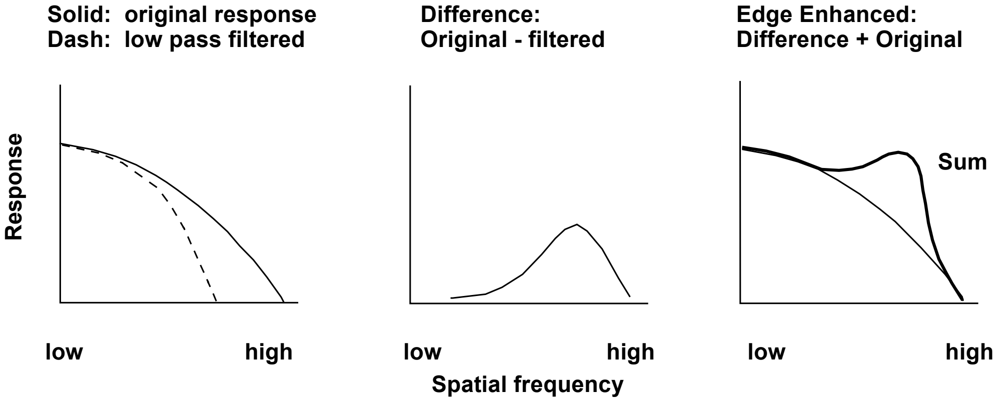


Figure__. The steps required for edge enhancement: Left: an original image frequency response (solid line) is blurred by a convolution filter to eliminate high frequency signals (dashed line). Middle: subtracting the blurred image from the original creates a difference signal with frequency components dependent on the amount of blurring. Right: the difference signal is added back to the original image and normalized to provide a mid- to high frequency boost in the filtered image.

AGFA modifies sharpness of the image by the same technique that accomplishes global contrast enhancement and normalization, e.g., selective modification of coefficients of the decomposed image. The enhancement becomes apparent upon reconstruction of the image. The user controls the distribution of effects among the sub-bands by selecting the magnitude and combination of MUSICA parameters. MUSICA affords three distinct parameters for modifying sharpness - MUSI contrast, Noise Reduction, and Edge contrast. MUSI-contrast amplifies subtle objects while attenuating prominent objects, without respect to object dimensions. A side effect of MUSI contrast is an increase in granularity of the image. Noise Reduction is a compensating MUSICA parameter, which attenuates high frequency sub-bands where noise would appear. Edge contrast, the complement to Noise

Reduction, boosts high frequency sub-bands, creating an effect that is similar to the Unsharp-Mask technique. Generalized image grayscale enhancement and frequency processing examples of a PSP chest image are illustrated in Figure 14.

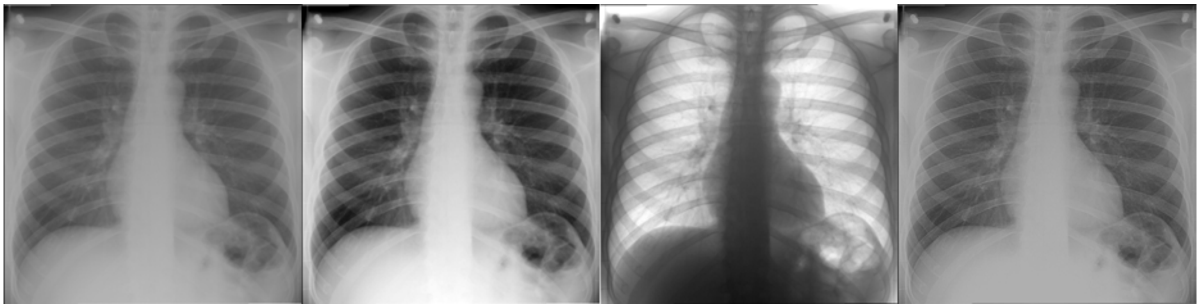


Figure 14. Example chest images demonstrating the flexibility of PSP systems and variable contrast enhancement available. Left: original "raw" chest image without contrast enhancement. Left center: contrast enhancement applied. Right center: "black-bone" or reversed contrast—often helpful in identifying tube placement. Right: edge-enhanced image.

3.3 Other Image Processing.

Manufacturers have developed special processing software to address specific PSP applications. These include but are not limited to Dual Energy Subtraction and Tomographic Artifact Suppression supplied by Fuji [].

4. IMAGE DEMOGRAPHICS AND EXPOSURE INDICATORS

4.1 Demographics and processing parameters

It is very important to understand and be able to decode the information available on the hard copy film or the soft-copy image, independent of the PSP system installed. Review of the specific manufacturer's user manual will contain all of the pertinent information. A summary of the information should be posted at all reading areas and the PSP equipment. In addition to the standard institution and patient demographic information, several important image processing parameters are listed, including image magnification/reduction factors, type of LUT's used for processing, frequency enhancement settings, latitude of the image data, and incident exposure information, among other vendor-specific factors. Even though a PSP system is manufactured by a specific company, re-sellers will "brand" their own demographics, notations, and positions on the image, or limit features (e.g. mark reprinted film with different parameters not the same as the original manufacturer). The user must be aware of these changes, and not assume that the information is identical or provides the same results. Specific user/application manuals for the PSP equipment must be consulted.

4.2 Exposure indicators

The PSP system can provide proper optical density or image luminance for under or over exposures because of a wide latitude response and ability to scale the signal. Potential problems with inappropriate techniques can therefore be masked. As a result, it is important to have an indicator of the average incident exposure on the imaging plate to verify proper radiological techniques. Each PSP manufacturer has a specific method for providing this information. In the case of Fuji, a ***Sensitivity*** number is reported which is inversely proportional to the incident exposure. Kodak provides an ***Exposure Index***, which is directly proportional to the logarithm of the exposure. AGFA provides an indicator called ***lgM***, whose value also varies proportional to the logarithm of exposure.

Fuji PSP systems use a ***sensitivity number*** to provide an *estimate* of the incident exposure on the plate transmitted through the object (if any) for the automatic and semi-automatic modes of operation. Under normal processing conditions for the standard resolution (ST) plates, the system sensitivity number for non-filtered 80 kVp beam is given as [Fuji tech rv#3, 93]:

$$S \cong \frac{200}{\text{exposure (mR)}}$$

A low incident exposure on the phosphor receptor results in a low PSL signal. In this case, amplification of the signal is required to obtain the optimal analog signal range for digitization. The amount of amplification (or de-amplification when an overexposure occurs) is indicated by the system sensitivity value. As opposed to screen-film systems, PSP systems offer flexibility in exposure levels. An average photostimulated luminescence within the area sensed by the reader is *estimated* as 1 mR (80 kVp, no object, no added x-ray tube filtration other than inherent) when the system sensitivity number is equal to 200 with the “semi-automatic” or “automatic” mode. This corresponds to a digital value of 511 (the central value of the 10 bit grayscale range), and to roughly the speed of a 200 speed screen-film combination from Fuji. (A 400-speed screen/film combination requires approximately half of the incident exposure). For the *fixed* sensitivity mode available with the Fuji PSP reader, the system response is similar to a screen-film detector. Calibration of the system sensitivity response is part of the acceptance test procedures. The system sensitivity response varies with kVp and beam filtration. It is important to recognize the sensitivity number as only an *estimate* of the incident exposure on the detector, not an absolute value.

Kodak PSP systems use an ***exposure index,*** a value reported by the reader that is directly proportional to the average log incident exposure on the plate, and is calculated as [Bogucki, 95]:

$$EI \cong 1000 \ \times \ \log(\text{exposure in mR}) \ + 2000$$

An exposure of 1 mR (80 kVp, 0.5 mm Cu, 1 mm Al filtration) results in an exposure index of 2000. An exposure of 10 mR leads to an exposure index of 3000, and an exposure of 0.1 mR will result in a value of 1000 for a calibrated system. Doubling the screen exposure results in an increase of 300 in the exposure index value. When using high-resolution PSP receptors, the exposure index has different ranges (see Kodak appendix).

AGFA PSP systems utilize an exposure indicator called ***“lgM”***, which is the logarithm of the Median exposure value of the raw histogram. Every AGFA PSP examination is assigned a Speed Class, and the system compensates for exposure variations of a factor of 4 around the intended speed. The lgM value indicates the actual exposure to the imaging plate by a mathematical relationship to the ***Scanned Average Level (SAL),*** which is just the average grayscale value. A 2.2 mR (20 uGy) exposure to the imaging plate using 75 kVp and 1.5 mm added Cu developed with a Speed Class of 200 results in an SAL of 1800. As a result of square-root amplification of the PMT output, the characteristic response of SAL with Speed Class of 200 is as follows:

$$SAL_{200} = 1214 \text{ x } \{[\text{exposure(mR)}]^{0.5}\}$$

The SAL value increases with the square root of the Speed Class, S, such that

$$SAL(S) = SAL_{200} \text{ x } (S/200)^{0.5}$$

Grayscale values are remapped to a logarithmic scale of exposure, where 4095 equals 3.2768 and zero is undefined. The relationship between lgM and SAL is given by

$$lgM = 3.2768 - \log[(4095/SAL)^2]$$

Combining these three equations and simplifying, an exact relationship between lgM and exposure for a is revealed,

$$\text{exposure (mR)} = [(2276/S) \text{ x } (10^{(lgM - 3.2768)})]$$

From this equation, it can be determined that a change of 0.3 in the numerical value of lgM corresponds to a change in exposure by a factor of two. Although the absolute numerical value of lgM depends on Speed Class, the *relative* change between lgM and exposure is valid regardless of Speed Class. Therefore, lgM is expressed in "lgE" units, which correspond to *bels (B).*

This relative exposure paradigm is incorporated into dose monitoring software that is an option on AGFA PSP systems. For each examination, view, and cassette size, an average value of lgM is either calculated over 50 exams or established manually. For each subsequent examination of that type, view, and cassette size, the lgM value is compared to the nominal lgM. The dose offset is reported both numerically and in the form of a thermometer graphic. The nominal lgM values and average statistics for the last 100 exams of each type can be printed or made available in electronic form.

4.3 Exposure concerns when using PSP systems

The exposure indicator estimate of the incident exposure to the PSP receptor is sensitive to segmentation algorithms, effective energy of the beam (kVp, filtration), delay between exposure and readout, positioning of the patient relative to the phosphor, and the source-image distance, among other factors. Because the PSP system provides a nearly optimal display of the anatomical information *independent of exposure*, this number is a very important aspect of quality assurance, patient care, and training issues. Recent publications [Seibert etal, 96; Huda etal 96] indicate the optimal exposure range for many clinical imaging procedures such as chest imaging requires an x-ray technique corresponding to a ~200 speed screen-film detector system, based upon the empirical analysis of images and characteristics of the PSP image acquisition process. For extremities, a higher exposure should be employed (e.g., 50 to 100 speed, like extremity screen-film receptors), while for pediatric imaging a lower exposure is recommended (e.g., 400 speed). PSP receptors that are underexposed can be identified by increased quantum mottle caused by an insufficient x-ray flux, resulting in a reduced signal to noise ratio and loss of contrast detectability. For certain studies with detection tasks not requiring a high signal to noise ratio (e.g., naso-gastric tube placement), exposures *can* be reduced significantly. On the other hand, overexposures are not as easily identified by appearance only and usually do not impact the usefulness of the image, but represent a disservice to patient care and proper radiation safety regulations. Visual cues on each printed film or soft-copy image can alert radiologists and technologists that the exposures are outside "normal" limits. Optimal radiographic techniques for PSP receptors might differ from screen-film receptors, particularly for the kVp setting because of the inherent differences in the phosphor composition and digital post-processing of the image. Technologists should be advised to adjust their techniques for grid and no-grid examinations by adjusting the mAs according to the Bucky factor. This will keep the quantum noise reasonably consistent from image to image.

5. PSP IMAGE CHARACTERISTICS

5.1 Spatial Resolution

High contrast (limiting) resolution in PSP is determined by several factors. Physical limits imposed by the composition and thickness of the phosphor plate, the size of the laser spot, temporal lag of the PSL, and light scattering within the phosphor contributes to the modulation and loss of the "pre-sampled" signal. The finite diameter of the laser spot incident on the phosphor layer and the spread of PSL, particularly at depth, contribute to unsharpness, as shown in Figure 15. Digital image pixel size is between 100 and 200 μm, and determines the maximum *spatial resolution* of the system, up to physical limits imposed by the composition of the imaging plate and the size of the laser spot. Digital sampling confines the maximum spatial frequencies accurately contained in the output image to a maximum determined by the Nyquist frequency, equal to the inverse of twice the pixel dimension, $(2\Delta x)^{-1}$. Unlike conventional screen-film cassettes, smaller phosphor plates will often provide better limiting resolution than larger plates, because the pixel size is related to the plate dimension. Resolution sharpness can be increased with the use of a thinner phosphor layer using high-resolution PSP receptors as shown in Figure 16; however, lower detection efficiency requires a higher radiation dose. Phosphorescence lag causes the spatial resolution in the fast scan direction to be slightly less than that in the sub-scan direction as depicted by the MTF curves in Figure 16, although one might expect more precision from an electro-optical motion than from a mechanical motion.

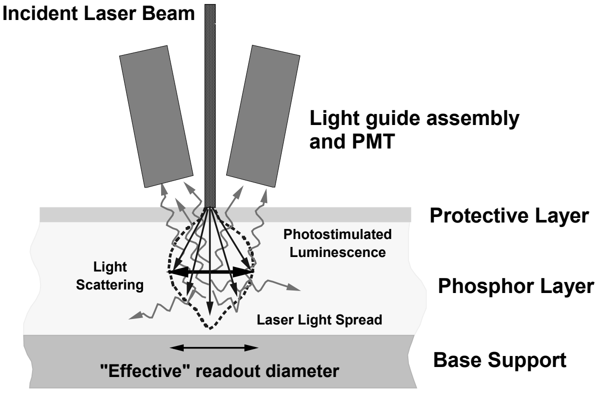


Figure 15. The effective area of the phosphor simultaneously stimulated by the laser is determined by the incident laser diameter, laser light spread within the phosphor, and the distribution of the PSL collected by the light guide assembly. This spread reduces the modulation of higher frequency signals. Adapted from Kato[Kato, 94].

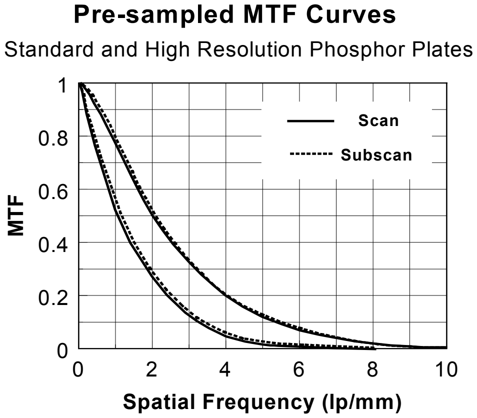


Figure 16. Typical results for pre-sampled MTF curves with PSP receptors are illustrated. The curve pair on the left are for standard resolution (thick phosphor) and on the right for high resolution (thin phosphor). Solid and dashed lines distinguish the scan and subscan MTF's, respectively. Adapted from Dobbins [Dobbins, etal 95].

Aliasing (pre-sampled high frequency signals beyond the Nyquist frequency reflected back into the image at lower spatial frequencies), can negatively affect the PSP image. This artifactual signal is caused by inadequate sampling, which in turn is limited by the size of the pixel and the digital image matrix. For instance, if the intrinsic resolution limit of the phosphor plate is 5 lp/mm, and the pixel sampling rate is 5 pixels/mm, or 2.5 lp/mm, the spatial frequencies in the signal spectrum beyond 2.5 lp/mm will be reflected back into the image below 2.5 lp/mm. Aliasing can be reduced in the (fast) scan direction with a low-pass filter to reduce or eliminate these high frequency signals. Smaller and/or high-resolution phosphor receptors with improved frequency response will be subjected to greater aliased signals. The impact of aliasing enhances image noise and reduces the detective quantum efficiency of the PSP receptor. Notable examples are the aliased signals generated by anti-scatter grids with lead strip frequencies beyond the Nyquist frequency, as illustrated in Figure 17. Anatomical signals projected onto the image are generally of low contrast and low frequency, and therefore are not aliased.

Figure 17. A low frequency anti-scatter grid causes aliasing in this digitally acquired image.

5.2 Contrast Resolution

The minimum difference in a "noiseless" signal that can be represented between digital pixels in the image depends on the total number of possible code values (quantization levels), as well as the target signal amplitude relative to the background. In most PSP systems, pixel values change with the logarithm of photostimulated luminescence, or equally with the logarithm of radiation dose to the plate, so the numerical difference between pixel values is the contrast. *Contrast sensitivity* or *detectability* of a PSP system depends not only on the number of bits used to represent each pixel, but also by the gain of the system (e.g., # electrons/x-ray photon, # x-ray photons per analog to digital unit) and overall noise amplitude relative to the contrast difference. The ability to differentiate a signal in the image is strongly dependent on the inherent subject contrast (kVp, scatter acceptance), amount of noise (x-ray, luminance, electronic, fixed pattern noise sources), image viewing conditions, and the limitations of the observer to discern regions of low contrast with respect to size.

Contrast detectability that is provided by the PSP image is, in general, similar to the screen-film image. As a digital detector, the PSP device permits the separation of latent image acquisition and display processing steps. Radiographic contrast is achieved with the application of examination specific gradation, tonescale, or other image manipulations. Without digital enhancement, the visible contrast of the resultant image is extremely low because of the wide exposure latitude (see the characteristic curve response in Figure 9). Unlike screen-film detectors which are *contrast limited* at a particular radiographic speed (the classic tradeoff between detector latitude and film contrast) the PSP image contrast is *noise limited*. There are several noise sources that contribute to the overall noise in the image. The random variation of *absorbed x-rays* in the PSP receptor determines the quantum noise component. *Stimulated luminance variations* during the readout process contribute significant variations in the output signal. *Quantization noise* adds inaccuracies in the determination of the discrete digital signal amplitude values (this is dependent upon the bit depth of the ADC, typically 10 to 12 bits in current systems). *Electronic noise* sources cause a further variation in the output signal. To approximate the typical image noise in a 400-speed film (and thus achieve similar contrast detectability), the PSP receptor (using standard resolution plates) requires a higher x-ray photon flux by about a factor of 2 times (e.g., a 200 speed system) [Seibert etal 96]. Note that display sharpness determined by image processing may influence the appearance of noise. Lower detection efficiency of the phosphor plate relative to a typical rare-earth dual-screen cassette is the chief cause.

5.3 Detective Quantum Efficiency

The Detective Quantum Efficiency describes the efficiency of information detection with respect to spatial frequency. It is dependent on the quantum detection efficiency of the screen and the noise associated with each process involved in creating the final image. This includes the number of trapped electrons per absorbed x-ray photon, noise in the stimulation and emission of the latent image, noise in the conversion to an electronic signal, noise associated with the digitization, and noise occurring in the final output image presentation. The large area, zero frequency DQE of a storage phosphor has been described as [Barnes, 93, Lubinsky 87]:

$$\mathrm{DQE}_{\mathrm{PSP}} = \frac{X_{\mathrm{abs}}}{[1+\mathrm{CV(E)}][1+\mathrm{CV(el)}][1+\mathrm{CV(S)}] \;+\; <g>^{-1}}$$

where: X_{abs} = fraction of incident x-ray photons absorbed in the phosphor layer

CV(E) = coefficient of variation of the x-ray energy absorbed in the phosphor layer

CV(el) = coefficient of variation in the number of trapped electrons for a given absorbed energy

CV(S) = coefficient of variation of the light signal emerging from the phosphor for a given number of trapped electrons

<g> = the average number of photoelectrons detected at the photomultiplier per absorbed x-ray (the large-area response function)

The energy dependence of X_{abs} is plotted in Figure 4. CV(E) depends on the overlap of the spectrum with the k-edge of barium and the fraction of K characteristic x-ray escape. For an 80 kVp x-ray beam transmitted through the patient, a value of ~0.15 has been estimated, similar to the CsI phosphor used in image intensifiers [Barnes, 93]. Hundreds of electrons are trapped in the phosphor F-centers per absorbed x-ray photon, making CV(el) relatively small (<0.05). On the other hand, the variation of stimulating laser light with depth in the phosphor and a similar variation of emission light with depth makes the luminance noise value CV(S) quite high, estimated to be on the order of 0.8 [24]. Large-area gain in the phosphor, <g>, is ~ 10, and results in the value in the denominator of the DQE expression ≅ 2. Thus, the DQE(0) can be estimated as approximately 1/2 X_{abs}. At 80 kVp with a typical transmitted x-ray spectrum through a patient, DQE (0) ≅ 0.25 for standard resolution and DQE(0) ≅ 0.13 for high resolution phosphor plates. These values approximate the published findings of Dobbins[Dobbins etal 95] and Hillen[Hillen etal 87]. Values of DQE(f) has been thoroughly investigated for several generations of storage phosphor imaging plates[Dobbins etal 95, Samei, SPIE97]. A steady improvement in the development of phosphor plate technology and subsequent detection efficiency as a function of spatial frequency has been demonstrated. Comparisons of the latest generation PSP phosphor plates to screen-film detectors is very favorable in terms of overall response and image quality.

5.4 Image Display

Laser Film Printers convert the digital images to film images to mimic the conventional screen-film radiography paradigm, where the film is trans-illuminated for viewing. With some PSP systems, the image size must be reduced (de-magnified) by a variable amount, depending upon the phosphor plate size and output film format. Hard copy presentation of the PSP image commits the user to a single rendering, obviating a major advantage of convenient display processing. In order to provide two different grayscale/edge enhancement renderings, the image size may be further reduced to accommodate two images on a single film. This two-on-one format requires a reduction to 50% of the 35 × 43 cm (14 × 17 inch) field of view on small format PSP films (~26 × 36 cm). Size reductions complicate direct measurements on film and make comparisons of films with size differences more difficult. Full field of view printing is available on 35 × 43 cm format film, with sampling matrices up to approximately 4000 × 4000 pixels (~3500 × 4300 by one manufacturer) to provide high spatial resolution on the order of 5 lp/mm over the full field of view. In networked laser printers, large film printing is available for a range of digital matrix sizes by interpolation and extrapolation of the digital image data. Slight size reductions of 5% occur with many laser printers in this large format.

CRT Monitors are used for “soft-copy” display. Digital images from the PSP reader are displayed on CRT monitors for a variety of purposes, including verification of correct patient positioning, Quality Control review and image modification, primary diagnosis, and clinical reference. Monitor capabilities, image manipulation toolkits in the associated workstations, and the criticality of display properties vary according to function. In general, high resolution, high luminance, multiple displays for primary radiological diagnosis, a referring physician display terminal of intermediate resolution, and a conventional color monitor / personal computer system represent the three levels of monitor quality. CRT monitors provide for simultaneous viewing of images throughout the hospital and for real-time modification of image appearance by the observer. Monitors share a number of characteristics, including lower luminance levels than a standard lightbox or film alternator, an image produced by fluorescence emission rather than by trans-illumination, an inherently nonlinear display transfer function, potential for fading, geometric distortion, and defocusing. If the monitor is linked to production of hard copy images, matching the appearance of the image on the monitor with the film is an important consideration. The adverse effect of high ambient light levels on the appearance of the image is more problematic with a CRT than with a trans-illuminator because of the lower CRT luminance. In addition, CRT phosphors produce different colors and have difference phosphorescence lag when changing images. An increased emphasis on the acceptance testing and quality control of display monitors and viewing conditions is necessary to ensure optimal image rendition.

6. SYSTEM CONFIGURATIONS AND DIGITAL SOFT/HARD-COPY INTERFACES

The diagnostic radiological physicist is likely to encounter PSP devices manufactured by any of several vendors. These devices often represent different generations of technology and exist in different functional configurations. A specific system configuration can significantly affect how the physicist conducts acceptance tests. The display media, display processing and content of the digital image data file varies depending on system configuration.

Many PSP devices operate as general-purpose devices inside or outside the radiology department. In this application, an imaging plate is inserted into the device and a dedicated laser camera produces a film. Other PSP devices are dedicated to acquisition of upright examinations of the thorax (Konica, Fuji, and Kodak) and may be integrated into the x-ray generator. Some PSP devices are constructed into a radiographic table (Fuji FCR 502, FCR 9502). In some hospitals, PSP devices are operated independently with dedicated laser printer, while in others, PSP devices are used to acquire digital data for a picture archiving and communication system (PACS).

Two decades of research and development, combined with advances in computer technology, have resulted in major improvements in PSP devices [Kato, 94, Fuji Tech Rev#2]. The integration of PSP devices and the development of commercial PSP devices have followed a parallel path. A PSP device is a system that must provide the user with several functions to be clinically useful. In addition to acquiring digital data representing the projected x-ray beam, the integrated system must provide a facility to process, store and render the resulting image data for display. This section reviews possible configurations of devices available at this time.

Early Clinical PSP Devices. The first PSP imaging devices were developed in the early to mid 1980’s. The first devices in the U.S. were clinically implemented by Philips Medical Systems in 1983, the Fuji Computed Radiography (FCR) 101 and FCR 201 [CBMerritt chest imaging summer school]. These devices were termed the *central processing type* [Fuji Technical Review #2]. These early devices, now obsolete, were large enough to fill an average size x-ray room, expensive to obtain and operate, and slow to process plates. Image data could only be printed on a dedicated laser camera. No convenient mechanism was provided to move image data outside of the manufacturer’s domain. These early systems were not commercially successful, however, they did establish the data processing model to be used for the next generation of PSP devices.

Independent PSP reader with dedicated laser printer. The second commercially available generation of PSP devices developed by Fuji was the 7000 series, termed the *distributed processing type* [Fuji Technical Review #2]. Fuji marketed the system in the U.S. through Original Equipment Manufacturer (OEM) relationships as a replacement for screen-film imaging. Most of these systems were standalone, providing all of the necessary data processing support in a single functional unit. Film output to a dedicated laser camera remained the standard method of rendering images, and no method for storing or reprocessing image data was initially provided. Laser printers that could accept multiple PSP device inputs provided some economy of scale.

Independent PSP Reader with Optional Digital Output. The OEMs, most notably Philips Medical Systems, realized the potential of integrating output from PSP devices into other information management systems. In conjunction with AT&T Bell Labs, Philips developed the “Easy Vision” Radiographic Workstation that included a proprietary hardware and software interface to the FCR 7000. Early attempts to develop remote data processing and display workstations were limited by the state of the PSP device interfaces and computer technology. It was clear at that time that significant benefits to the practice of radiology could be gained by separating the acquisition, storage, transport and display of medical images [ref. U Arizona].

The first commercially successful PSP device was the AC family developed by Fuji. By this time, the size and cost of the device had been significantly reduced. Processing throughput was markedly improved over earlier versions. The device was no longer marketed as a departmental replacement for screen-film systems, but rather as a method to provide imaging solutions for the emergency room and intensive care units. The AC-1 was a standalone system with an attached film processor. The same laser that scanned the imaging plate was used to expose the laser printer film. No capability for storing or reprocessing of digital data was provided.

As PSP systems evolved, so did the radiology department’s ability to provide digital image storage, transport and rendering of digital images. Shortly after the introduction of the AC-1 system, Fuji introduced the AC-1+ and AC-2 systems. These systems provided optional access to digital data from the proprietary Data Management System (DMS) via a Small Computer Systems Interface (SCSI) adapter. The Fuji Digital Laser Reader - Digital Acquisition System Manager (FDLR-DASM) was supplied by a third-party vendor (Analogics, Inc. Maynard, MA). The AC-2 did not have an attached film processor, but had an option to print laser film to a magazine. The FLDR-DASM was also an option for the FCR 7000 series scanners. Siemens Gammasonics (Chicago, IL), another OEM, developed a Macintosh-based Computed Radiography Acquisition Workstation using the DASM, and transmitted data via a proprietary network protocol. For the first time, digital image data could be moved from the PSP device to a remote computer system.

Independent PSP Reader with Quality Control (QC) Workstation. The data available through the FDLR-DASM, however, was not fully processed by the PSP device, and required additional image processing to match the appearance of the film output. Early use of these interfaces was largely limited to academic institutions [Templeton, et al. 1992, Journal of Digital Imaging]. Fuji subsequently introduced the HIC-654 computer workstation to interface to the AC-1+ and AC-2 via the proprietary DMS interface. The HIC-654 provided the capability to temporarily store data onto a local disk drive, reprocess image data stored on disk, print the reprocessed data and provided processed through a FDLR-DASM.

Independent PSP Reader with QC Workstation and Networked Laser Printer. Kodak introduced its first PSP device, the Kodak Ektascan Storage Phosphor Reader (KESPR) 3000 series in 1992. This was the first PSP system that was designed as a data acquisition node for output to a network for image storage, hard copy recording, and diagnostic soft-copy display. The KESPR consisted of the PSP reader device interfaced to a dedicated computer workstation that provided image storage and reprocessing capabilities. Fully processed images could be moved from the computer workstation to remote computer systems and shared laser printers in accordance with the ACR-NEMA Version 2.0 standard for medical image communications [ref 7].

Networked PSP reader with Networked QC Workstation and Networked Laser Printer. CEMAX (Milpitas, CA), a third party vendor, introduced the first commercially available network interface adapter (NIA) for a PSP device. The NIA relied on the FLDR-DASM and connected to a standard Ethernet network. Another third party vendor, DeJarnette Research (Towson, MD) introduced a similar NIA that conformed to the ACR-NEMA DICOM 3.0 standard [ref7]. Analogics has recently developed the SD100 “SuperDASM” that fulfills the same function. GE (Milwaukee, WI) has also developed a combined QC workstation and NIA for Fuji PSP devices. At this writing, Fuji, Kodak and Agfa produce PSP readers. All manufacturers have the capability to transfer data processed data to attached laser cameras and to remote computer systems and laser printers via networks using the DICOM 3.0 communications protocol. At this writing, Agfa is the only PSP manufacturer whose PSP reader communicates directly to the network according to DICOM 3.0 conventions.

Non-standard Access to Digital PSP Data. In the quest for access to digital PSP data, a number of ersatz methods were developed, including “screen dumps” of the video driver of a workstation to its local hard drive and down-sampling of full-resolution PSP data. It is important to recognize that data captured by these methods did not include display processing and did not include the full gray-scale resolution or pixel matrix of the original PSP image file.

Acquisition and Association of Patient Demographic and Exam Information. Early PSP devices required the operator to manually enter patient demographic and exam information associated with each PSP image. As PSP devices became integrated into radiology operations, more efficient methods were developed to acquire this data including creation of magnetic cards, bar codes, and ultimately, functional interfaces with the Radiology Information System. In order to perform acceptance tests on integrated PSP systems, the physicist may have to create phantom patients in the RIS corresponding to the planned test exposures.

7. GENERIC FUNCTIONAL SPECIFICATIONS OF PSP SYSTEMS

Functional specifications related to “typical” capabilities/specifications are listed based upon a recent review of vendor literature. It is highly recommended to communicate with marketing specialists and system engineers to determine the up-to-date capabilities/specifications of a particular PSP system prior to purchase, installation and testing.

7.1 Phosphor receptors and cassettes

Several receptor and cassette sizes are available for PSP systems. The most popular sizes include 35 cm × 43 cm (14" × 17"), 35 cm × 35 cm (14" × 14"), 24 cm × 30 cm (10" × 12"), 24 cm × 24 cm (10" × 10") and 18 cm × 24 cm (8" ×10"). Specialized cassettes (e.g., 20 cm × 20 cm) are also available as options from certain manufacturers. The time required reading the phosphor plate is dependent on the plate size. Larger sizes usually take longer to read, and decrease overall system throughput. Spatial resolution is also affected by phosphor plate size. In general, the larger the plate size, the poorer the limiting resolution. Plate inventory should be sufficient to eliminate delays due to accessibility of plates, and not by the throughput of the PSP reader. Related to the second item, it is highly recommended to have two or more PSP systems in busy work environments for redundancy in the event of system malfunctions. Standard resolution and high-resolution image receptors are available from the manufacturers, and should be considered relative to the imaging application. A tradeoff of detection efficiency for slightly better spatial resolution requires approximately three times more exposure with the high resolution detector to achieve an equivalent signal to noise ratio.

7.2 PSP receptor throughput

A range of ~30 screens per hour up to ~110 screens per hour are specified by the various manufacturers, which depends on the equipment and options purchased. PSL decay time is the major limit to the throughput speed, although in some systems, plate handling and erasure requirements can add substantial time for the transit of a plate through the reader. Some PSP systems have internal stackers or external automatic handling capabilities to allow the user to accomplish other functions without having to wait for the total readout process.

7.3 Spatial resolution

Spatial resolution is chiefly dependent on the reading and recording laser sampling pitch over a given field of view (phosphor plate size), which determines pixel size. Most PSP reader systems utilize a laser beam with an effective 100 μm diameter spot size on the phosphor. The output sampling pitch is determined by the number of pixels across the receptor, and in most cases is greater for larger sizes. PSP receptor characteristics such as phosphor coating thickness (e.g., standard versus high resolution, see figure 16), protective coating layer thickness, finite laser beam dimensions, light scatter in the phosphor, and frequency response of electrical circuits will impact the limiting resolution. A range of specifications exist, dependent on the size of the imaging receptor, the type of PSP reader, memory options, and image output options, among others. In general, intrinsic spatial resolution ranges between 2.5 to 5 lp/mm (0.2 mm to 0.1 mm object detail) dependent on receptor size, which is somewhat inferior to a 400 speed screen film intrinsic resolution capability of about 7 lp/mm (0.07 mm object detail).

There are several generations of PSP receptors with different physical and performance characteristics available from the manufacturers. "Standard resolution" and "high resolution" plates are often used in the same PSP reader. The former is typically used for all applications in general radiography; while the latter is used for extremities and mammography applications. The thickness of the standard resolution plates is approximately 2 times greater than that of the high-resolution plates. Higher quantum detection efficiency and better contrast resolution is obtained with the sacrifice of spatial resolution. Discussion of resolution factors, MTF measurements and detective quantum efficiency issues are found in the literature [Kato,94;Dobbins etal 95]. CRT (soft copy) displays also influence spatial resolution, and will likely be the limiting factor for displaying image matrix sizes that exceed the bandwidth and number of TV lines of the monitor. This can be overcome with partial image display to the intrinsic resolution limit (without pixel replication or interpolation) by sacrificing the display field of view.

7.4 Contrast sensitivity

Optimally tuned PSP systems with low electronic noise will have contrast sensitivity chiefly determined by image acquisition techniques (kVp, antiscatter grid, geometry, etc.), processing parameters (display gradient, frequency processing, noise filtering) and detective quantum efficiency of the PSP phosphor. A major equipment issue is the bit depth of the pixel, which determines the number of discrete graylevels that encode the contrast differences. Ten bits has been shown to be sufficient for film recording [Kato, 94]. However, there is a potential to lose image information if the scaling algorithms or histogram analysis is improperly applied in some systems that use 10 bits of output signal quantization. Twelve-bit pixel accuracy is preferred because the total exposure dynamic range is encoded in the digital image, so recovery from inappropriate automatic processing is possible.

7.5 Dynamic range

The incident exposure sensitivity of the PSP receptor typically extends from 0.01 mR up to 100 mR (a range of 10,000 or 10^4). In some systems, a “high gain” setting can reduce the lowest detectable exposure to 0.001 mR, but this also reduces the high end to 10 mR maximum. A logarithmic amplification linearizes the exposure-luminance response curve. (Note: in Agfa systems, a “square-root” amplification is used in lieu of log amplification.) Intrinsic detector and subject contrasts are typically very low, and not clinically optimal. (“Four decades” of dynamic range is attributed because of this tremendous exposure response – however, rarely are four decades of dynamic range required *or desired* for diagnostic radiology applications.) The range of exposures containing the *useful* image information is identified with image analysis of the digital distribution on the raw image, usually by *histogram analysis*. Examination specific algorithms evaluate the distribution and shape of the resultant histogram, followed by linear/non-linear contrast stretching and enhancement to mimic screen-film presentations and/or radiologist preference.

7.7 Desirable Specifications and Features

Phosphor plates, cassettes, grids, identification terminals

Enough phosphor plates and corresponding cassettes should be ordered to meet 1.5 times the peak demand for imaging services. Consider the different sizes of phosphor screens, and the number that can be stored in an internal stacker, if any. Stationary, low frequency grids can be problematic with digitally sampled images, including PSP systems. High frequency grids (e.g., >140 lines/inch, >55 lines/cm) and multi-hole grids are available to alleviate problems with aliasing and moiré patterns, and should be considered as part of the system purchase. Cassette identification terminals electronically correlate the patient to the cassette, and provide the examination-specific processing instructions. Sufficient ID terminals placed in convenient, strategic locations in the work environment is important to avoid workflow bottlenecks and throughput problems.

Output image characteristics

Output image format of 1:1 magnification using 35 × 43 cm (14 × 17 inch) receptors is not available on some PSP systems, where reduced size images (e.g., 2/3 size of the original) are standard. Alternate printing (e.g., DICOM print services with networked laser printer) can overcome this limitation. Many laser printers reduce the actual image size by up to 5% (95% of "true" size that would be achieved on a screen-film detector). Thus, a statement regarding distance accuracy and distance calibration marks on the side of the films should be included in the specifications. Image shading corrections and factors that relate to image uniformity, dark noise, and signal to noise ratio should be mentioned in the bid specification document. These issues are discussed as part of the acceptance test procedures.

Incident exposure estimation; other data fields

Incident exposure estimates for PSP image acquisitions are extremely important, should be included on the image demographics as a requirement, and preferably tracked in a database for long-term analysis of trends. In addition, other performance indices and database functions should be considered. These include display of extremely high or low exposures, number of exposure cycles of each receptor (to track longevity), and processing parameters applied to the image, among other data fields.

Image processing functionality

Specific image processing capabilities should be listed. These include simple window/level adjustments, non-linear adjustments to mimic screen-film response, reverse contrast mapping, edge enhancement, dynamic range control, and fill-in of unexposed areas (e.g., to fill in the unexposed areas of the resultant image with dark or opaque boundaries – crucial for pediatric newborn studies and small objects). The ability to implement user-defined functions in addition to the built-in functions is desirable.

Patient demographics and film marker positioning

Systems should have the flexibility of allowing specific institutional, patient, phosphor plate, and technologist identification with a user-selectable font type/size and position on the image. Image processing parameters, exposure index, image magnification or minification, image reversal, and positioning markers should be available.

PSP system interfaces to RIS, HIS, Imaging Networks and PACS

Interface of the PSP system(s) to Radiology and Hospital information computers is necessary. Specific details regarding the in-house RIS/HIS vendor must be explained. In return, the PSP vendor should be expected to provide a standard interface (e.g., Health Level-7 [HL-7]) or other non-standard interfaces along with specific demographic information to be transferred. Automatic downloading and uploading of patient demographics, examination type, and scheduling times should be requested. A DICOM 3.0 conformance statement for interface to existing or future PACS infrastructure is essential. Interfaces to existing laser printers should be included in the bid, including DICOM printing functionality over a network. The vendor should describe the interfaces (e.g., are the interfaces implemented in the system design, or is extra peripheral hardware required in close proximity to the PSP reader?). As there are several capable third-party vendors that provide interfacing functionality, request the manufacturer to indicate an "approved" third-party vendor list that provides the desired functionality, and consider these alternatives. The assistance of knowledgeable experts is helpful for these complicated issues.

Quality control phantom set; quality control workstation/software

The vendor/manufacturer should provide a quality control phantom with the system. Spatial resolution, contrast detectability, exposure uniformity, exposure linearity, and distance measurement accuracy/aspect ratio should be testable. Ideally, a third-party phantom, specifically designed for "generic" PSP image performance, should be specified in addition to the system-specific phantom. Many PSP systems come with a quality control image workstation, which assists in measuring the performance of the system as well as providing a capability for the technologist to verify patient positioning and image orientation. Manual and automated quantitative tool such as region of interest pixel values/standard deviations and contrast to noise and maximum signal to noise ratios for QC image tests should be available. Results cataloged in a database and plotted versus time (daily, weekly, monthly) can reveal trends and performance indices to objectively determine compliance failures, and can indicate the need for preventative maintenance prior to a problem being manifested.

Service contracts, preventive maintenance, warranty and siting requirements

Consideration of hardware/software upgrades, phosphor receptor/cassette longevity, and system extended warranty should be included in any maintenance contract. Approved third party service or in-house radiological engineering support/training should be included as alternative options. Site preparation to include required power, air-conditioning/filtering, equipment footprint, configuration of the PSP readers, preliminary schematic drawings, etc., are all components of the specification document for consideration.

Application training for technologists, radiologists, physicists, clinical engineers

Specific reference to applications training should be indicated, even though the vendor typically has a standard level of applications training that goes with the sale of the equipment. A minimum of one-week on-site training is recommended for the technologists (include work shift specifications if necessary). This should be followed by a subsequent week of refresher assistance approximately one to two months after the initial training has taken place. Radiologists should also interact with the application specialist during the initial start-up of the system, so that specific image processing algorithms can be implemented according to their preference. Physicists should be aware of the processing algorithm function and be instructed on how to adjust image appearance and create user examination algorithms. Hospital engineering staff should be trained for simple preventative maintenance tasks and error recovery issues at the minimum.

8. CLINICAL IMPLEMENTATION ISSUES

8.1 Expectations and realities

The benefits anticipated by the introduction of PSP systems into clinical practice depend on the intended role. When PSP radiography is introduced as a replacement for screen-film as a receptor, the user expects to benefit from the improved consistency and decreased repeat rate when compared to conventional radiography. When PSP radiography is introduced to provide flexibility in the presentation of the image, the user expects to benefit from the ability to reprocess the digital image. When PSP radiography is introduced in order to replace film with a digital archive, the user expects to benefit from the convenience of storing images in electronic form. When PSP radiography is introduced to replace film with a digital image distribution and display system, the user expects to rely on PSP images exclusively for acquisition of ordinary radiographic examinations.

The clinical acceptance of PSP radiography depends in part on perceptions of comparisons with conventional screen-film for similar tasks. As a digital receptor, the PSP receptor and reader system has inherent spatial resolution limitations when compared to an analog system such as screen-film. On the other hand, while screen-film contrast sensitivity is fixed for a given radiographic technique, PSP systems can modify display contrast independently of subject contrast, and thus should be able to provide better contrast sensitivity.

A benefit of PSP radiography over screen-film is the ability to modify the appearance of the digital image to enhance conspicuity of clinical features. However, there is no universal agreement on the optimal set of processing values for an examination. The effects of display processing depend on radiographic technique, and too much “processing” can generate undesirable results. The ability for a knowledgeable operator to modify processing defaults introduces a configuration management problem: for consistency, it is important to assure that the same processing defaults are loaded in all PSP machines and identification terminals. Differences in processing methods between manufacturers mean that PSP images produced by identical radiographic technique with the same subject may not have the same appearance with PSP systems of different vendors. Comparison examinations over time should have the same image processing parameters to assist consistent clinical diagnosis.

8.2 Technical concerns

Because the first step in processing the PSP image is to locate the exposure field and ignore signals outside the field, patient positioning, x-ray beam collimation, and convergence of the light field and x-ray field are more critical than in screen-film imaging. Generally, the anatomy of interest should be centered on the imaging plate, collimation should be used to reduce the amount of beam that is unattenuated by the subject, and collimation should be symmetric and parallel to the edges of the cassette. Recent PSP systems are tolerant for such cases. Additionally, it is prudent to acquire only one image per phosphor plate. When one considers the potential for confusing the PSP reader with multiple images per plate, and a somewhat better spatial resolution for smaller cassettes, it is advised to project a single view on the smallest cassette possible, especially for extremity exams emphasizing bone rather than soft tissue. If the digital image is to be viewed on a CRT, views on separate receptors can be manipulated independently, unlike multiple views on a single receptor. If multiple views are to be used, it is helpful to place only similar views on a given receptor. The PSP reader algorithms may be able to segregate the views for histogram analysis, but appropriate display processing selected for one view must be applied to all.

Unlike screen-film radiography, the size of the cassette selected has a pronounced influence on the characteristics of the image. Approximately the same number of pixels are used to represent each PSP image, that is, about 2K × 2K, with the exception of the high resolution options by the various manufacturers of approximately 4K × 4K pixels for a 35 cm × 43 cm (14” × 17”) imaging plate. A smaller phosphor receptor has a smaller pixel dimension and better spatial resolution than larger receptors. There is another effect for hard-copy films, depending on the format of the laser printer: the images acquired with the smaller cassettes may be presented at 100% magnification, while those from the largest cassette may be presented in reduced size.

At this writing, we are at the sixth manufacturing generation of Fuji photostimulable storage phosphor image receptors, and at least the second Kodak generation. Agfa has introduced an image receptor with a different phosphor composition. Receptors of different generations differ in their x-ray capture and light generating characteristics, thus the PSP scanner should be calibrated specifically for a single receptor type. Some receptors may not be appropriate for a particular PSP scanner model because of laser light characteristics or hardware configurations. It is important to recognize that, while the manufacturer may only be supplying the current generation, there are many receptors of other generations in circulation. Clinical operation with mixed generations of receptors should be avoided unless it can be shown that variability in the outcome image quality is essentially unaffected.

8.3 X-ray scatter and grid selection

The lower k-edge of the PSP receptor using BaFBr(Eu) (k-edge of Ba at 37 keV) may confer a greater sensitivity to scatter than screen-film. Early versions of PSP cassettes did not have adequate backscatter control that caused artifacts. Apprehension about scatter has caused some practitioners to recommend scatter reduction grids for all bedside exams without regard to patient thickness.

The selection of an appropriate fixed grid for the PSP receptor is problematic. There is no universal agreement about what grid type, focused, parallel, or crosshatch, what grid ratio, intersperse material, or grid frequency to use. The general purpose 103 line per inch grid presents a periodic signal of about 2 lines pairs per mm, which is close enough to the sampling frequency for 35cm×43cm image receptors to cause aliasing artifacts, i.e. accentuated grid lines and moiré patterns. When the PSP image is displayed on a CRT, unfortunate selections of zoom factor can also generate moiré artifacts with 85 line per inch grids. Some manufacturers are recommending high frequency grids, which are more expensive and more difficult to use clinically. An alternative is the multi-hole grid. There is an indication that histogram analysis yields different results with and without grids. Specific menu selections (or processing algorithms) might be considered for grid and non-grid exams to produce optimal results on hardcopy films.

8.4 Radiation exposure

Current PSP systems tend to require more radiation to produce images of equivalent quality compared to 400 speed rare earth screen-film systems in common use today. PSP systems are much more tolerant of inappropriate technique than screen-film, and are capable of producing a diagnostic quality image under conditions of under- and over-exposure that would necessitate a repeated examination using screen-film. In other words, in the hands of an experienced user, PSP imaging allows the *choice* of exposure. Tolerance of inappropriate exposure factors with PSP radiography is a double-edged sword: under- and over-exposure are not obvious from the appearance of the normalized PSP image. Instead of a light or dark film, we must rely on derived indices of exposure that are based on the results of the normalization process in order to monitor patient radiation exposure. These indices and the way they are calculated differ among manufacturers, and are greatly affected by readout and display processing characteristics of the PSP device. There should be a thorough understanding of the exposure indicators and how they relate to receptor speed and estimates of patient dose (similar to the way estimates for screen-film detectors are determined). From a radiation management prospective, it is critical to insure that the index is reported along with the image in any clinical practice of PSP radiography. In addition, it is prudent to consider a method for periodic monitoring of the incident exposure indicator to identify undesirable trends of inappropriate technique (particularly the over-exposures, which are more difficult to identify by visual inspection of the image).

8.5 Phototimer calibration

In most clinical situations, the primary method of exposure factor control is the phototimer. Traditionally, phototimers have been designed to provide constant optical densities for a variety of kV and attenuation combinations. This requires that the exposure to the image receptor be controlled in a manner that is appropriate for the energy response of the receptor in use. It is important to recognize that the response of a PSP receptor is different from most conventional screen-film receptors. When setting up a phototimer station for use with a PSP device, the goal should be to produce a constant pixel value for a variety of kV and attenuation combinations. To accomplish this, the autoranging feature must be disabled during phototimer calibration. Under these conditions, the PSP response (pixel value) can be related to the receptor absorbed dose. Calibration of the phototimer can then proceed in a manner identical to screen-film systems using pixel value (or hard copy optical density) as the output variable to be controlled instead of film optical density. Alternatively, as in the case where autoranging cannot be disabled, patient (phantom) exit exposure can be used as the output variable to be controlled.

8.6 Technologist training

When PSP radiography is introduced into a conventional radiography operation, initial technologist retraining is imperative. The technologist must understand the importance of selecting the proper examination, must learn to recognize a new set of artifacts, and must have some idea how to correct for inferior images. Appropriate actions with PSP systems are often anti-intuitive to technologists well versed in screen-film radiography. As personnel changes occur, provisions for repeated training should be made, because most personnel will come from a film-based experience.

8.7 Radiologist acceptance

There are several factors adversely affecting radiologist acceptance of PSP radiography relative to screen-film imaging. Radiologists are trained to discern clinical features on film, the ACR teaching file is composed entirely of screen-film images, and for ABR boards they must demonstrate proficiency at examining screen-film images. PSP images have a different appearance from screen-film. The chief complaints of radiologists conform to several categories, namely:

1) A lack of confidence at the detection of low contrast, high liability features, such as pulmonary nodules.
2) Accentuation of some features, such as lung markings, that may cause overcalling of interstitial lung disease.
3) Discomfort with the finite limits of spatial resolution.
4) Dissatisfaction with less-than-life-size presentation either on small format laser prints or CRT displays.
5) Dissatisfaction with the additional radiation exposure required in certain applications.
6) Additional time required per study when viewed on a CRT because of the potential (or need) to manipulate the digital image.

To date, PSP system technology represents the current state-of-the-art in direct digital acquisition, manipulation and storage of two-dimensional projection radiographs, despite some of the above-mentioned limitations. When optimally adjusted, these systems provide image quality equivalent to optimal screen-film technology, and also give the ability to directly interface into a digital image network/PACS environment. To ensure optimal adjustments and image quality, acceptance testing and periodic quality control should be implemented. Issues related to these topics follow.

9. ACCEPTANCE TESTING

Acceptance tests of the PSP system are a first and crucial step towards clinical implementation. Verification of proper function, adherence to functional specifications as published by the manufacturer, documentation of reports, demonstration of personnel training, and establishing a standard for subsequent quality control tests comprise the rationale for these procedures. Several references on acceptance testing are available in the literature [Seibert, 94; Willis 94; Willis 95; Huda, 95; Jafroudi, 95; Cowen, 93; Willis, 96].

9.1 Preliminary Communication with vendor engineer/specialist

Prior to initiating the acceptance test procedures, an outline of the specific tests to be accomplished should be provided to the service engineer during installation. Perusal of applications manuals and other documentation that provides information about the PSP system, instructions for use and system specifications are extremely important. An itemized list of the components, peripherals, and options delivered with the system should be available. Communication with the service engineer, applications personnel, and sales representative is extremely helpful in getting knowledge about the system, its capabilities, and options.

9.2 Component Inventory

Imaging plates, cassettes, hardware, and associated documentation delivered with the system should be inventoried and inspected. Items to inspect include the proper installation of the main unit, the processor, power lines, exhaust ducts, water supply, developer/fixer replenishment tanks, hose connections, and environmental air conditioning. The phosphor plates are particularly vulnerable to mishandling. A careful, visual inspection of each plate is necessary. Surface defects or scratches are noted as found, and logged on the inventory checklist with the corresponding serial number. Each cassette should also be examined for loose or protruding screws/fasteners. Include all findings in the final acceptance test report.

9.3 Tools and equipment required for acceptance evaluation (minimum list)

- copper and aluminum plates/filters
- film densitometer and sensitometer (if a hard copy display is to be used)
- a steel ruler (at least 14" long, 1" wide)
- ≥ 10X magnification loupe with 0.1 mm graticule
- exposure dosimeter – calibrated ionization chamber
- high contrast square wave resolution test pattern with a range spanning 0.5 to ~10 lp/mm
- low contrast sensitivity/detectability phantom, e.g., Leeds test object[35], UAB contrast phantom[36]
- aluminum step wedge phantom for simple characteristic curve analysis
- anthropomorphic phantoms (chest, skull, foot, etc.)
- screen contact (wire mesh) test tool
- a repeatable x-ray source – 50 to 120 kVp and several 0.5 mm thick copper filters for tube filtration

- a flashlight
- a timer or stopwatch
- a measuring tape
- masking tape
- an anti-scatter grid (if the x-ray system does not have one)

9.4 Preparations and initial adjustments for acceptance test measurements

There are a number of adjustments and calibrations that must occur on the PSP system prior to acceptance tests and clinical service [Willis, 94]. These adjustments are typically vendor specific, and should be accomplished in concert with the service engineer at the beginning of the acceptance testing procedures

Customization of Alphanumeric Data Recording

Demographic information to be listed on each printed film or displayed image should be reviewed and checked for accuracy. Information includes but is not limited to hospital name, machine identification, display processing parameters, system sensitivity information, date, and time.

Adjustment of the hardcopy recording device

As most primary diagnosis is currently made with hard-copy laser films generated from the acquired digital data, the following steps must be checked to ensure proper operation.

(1) The film image is properly positioned on the film.
(2) Shading variations caused by non-uniformities in the laser-light intensity across the film are minimal.
(3) Processor chemistry is maintained at an optimal level.
(4) Internal laser calibration is within tolerance limits specified by the vendor.

There will typically be system-generated test scans available to assist in the verification of these parameters.

Film Processor and Laser Printer Tests

A film processor audit requires the verification of proper chemistry activity, replenishment levels, developer temperature, and lack of processor generated artifacts. The film processor should be evaluated according to the manufacturer's quality assurance recommendations as well as methods outlined in the literature [Wagner, LK 94]. The film processor chemistry and the developer temperature influence the optical density values of the printed films. It is advisable to independently test processor performance with sensitometric strip methods on a daily to weekly basis, depending on system use. This will allow any potential problems with the film processor to be uniquely identified and separated from those caused by the PSP system hardware and calibration mis-adjustment.

Laser printer calibration/Sensitometry

Laser-generated sensitometric strips should be printed to determine the proper laser performance and function, and to calibrate the printer when out of tolerance. Each test point of the laser-generated pattern is measured with a calibrated densitometer. The optical density values should fall within the tolerance limits indicated by the vendor documentation. Should the values fall outside the recommended density range, a correction (calibration) algorithm should be invoked (often under the guidance of the service engineer) and the test repeated. For a second failure, a request for repair should be initiated prior to doing other acceptance tests. In certain situations, the PSP system laser writer can compensate for variations of film processor chemistry or malfunction that can ultimately lead to a catastrophic failure. It is important, therefore, to understand and determine the degree of compensation effected by the laser subsystem.

Image workstation display monitor calibration/resolution tests

In a soft-copy environment, display workstations are a critical link in the overall image quality verification of a PSP system. A short list of items that should be evaluated initially and frequently via quality control tests are:

- Adjustment of brightness/contrast via SMPTE test pattern or equivalent[Joel Gray manuscript, DICOM sup 28,.
- Determination of high contrast spatial resolution, both centrally and peripherally
- Determination of geometric distortion, particularly in the periphery of the image
- Evaluation of luminance output with a luminance meter
- Evaluation of room lighting conditions with illuminance meter

Hardware and software tools to perform these tests should be specified in the original purchase agreement to be delivered with the system. This is an area critically important to image display and evaluation of the PSP system, where further work is necessary to describe and implement acceptance tests and quality control procedures.

Calibration and Characterization of the X-ray Beam

X-ray beam characterization of a calibrated x-ray system is important for achieving reproducibility in PSP system tests of sensitivity, linearity, and uniformity. A beam produced by a high frequency generator system that is likely to be available to the physicist for future QC testing is preferred. For general-purpose PSP systems, a standard 80 kVp beam with 3.0 to 3.5 mm aluminum equivalent HVL should be characterized. An identical beam, or nearly identical beam, should be used in subsequent QC testing and performance monitoring of the PSP system. Also, at the time of acceptance testing, identification of several image receptors to be set aside and safeguarded for the physicist's sole use in subsequent QC testing is highly recommended. For specialty PSP systems, more appropriate beams should be characterized and used (e.g., 110-120 kVp for a dedicated chest PSP system).

Sensitivity and linearity tests should challenge PSP system response under conditions representative of the clinical environment. To assist reproducibility, a simple filter of 1 mm copper plus 1 mm aluminum is recommended. The phantom should be placed at the collimator with the copper side facing the x-ray tube. Image uniformity tests may be conducted with or without the phantom.

9.5 Specific Testing Procedures

Once familiarized with the system parameters of the particular PSP system to be tested, proper function and adherence to specifications can be determined with the tests recommended in this section. Assessment of initial operating characteristics and measurements of all testable components is essential to determine baseline performance, and to ensure continued optimal functionality and image quality throughout the system's lifetime during periodic quality control testing and preventative maintenance service.

9.5.1 ***Phosphor Plate Dark Noise***

All imaging plates in the inventory must first be erased with the full erasure cycle to ensure removal of all residual signals from background radiation or other sources. The erasure unit subsystem is comprised of a high-pressure sodium or fluorescent lamp (this depends on the manufacturer and model number). After erasure, several plates (e.g., 3 to 5) should be scanned using an automatic scaling algorithm or fixed scaling algorithm to drive the gain of the system to maximum. (Note: some newer systems, when detecting a "dark-current" situation, automatically adjust the readout technique to a wide latitude, nominal exposure value; in this case, use a fixed manual technique and drive the system to a high amplification signal). The resultant film (or soft-copy image) for each plate should demonstrate a clear, uniform, artifact-free image (see appendix 3 for an exception). Exposure indicators for automatic processing should indicate no incident exposure. Obvious artifacts, density shading, or uniformities present on any output image should be evaluated further. If more than two plates of the test set have a problem, all of the plates in the inventory should be tested. Reproducible artifacts on a number of films, such as a uniform shading response, indicates the laser subsystem, light collection guide, memory board, erasure unit, or fogged film are potential problems. Corrective action is required before proceeding to other tests.

9.5.2 System Linearity, Auto-ranging and Exposure Response

This test determines the response of the detector and readout systems over greater than two decades of exposure variation (>100 times difference). A calibrated radiographic x-ray tube with reproducible output (kV accuracy better than ±5% and exposure output accuracy ±2%) and acquisition geometry / receptor orientation must be maintained. Suggested techniques are 80 kVp, 180 cm SID and 1 mm Cu + 1 mm Al filtration, with the beam collimated to the total receptor area. (Consult the manufacturer specified beam energy and tube filtration in the appendices to verify proper calibration of the exposure value.) Determine radiographic techniques to provide incident exposures of approximately 0.05, 1.0, and 10 mR. Actual incident exposure should be measured with a calibrated ionization chamber free in air (no backscatter) and calculated to the surface of the PSP receptor. At each incident exposure, acquire three independent images, and use a fixed delay time of 10 minutes between exposure and processing. Use a readout algorithm specified by the manufacturer for exposure value calibration, and verify proper incident exposures for each receptor. Repeat the process a total of three times (a total of nine images), being careful to use the same PSP receptor for a specific incident exposure measurement. Calculated exposure values should be within ±20% of the actual incident exposure for any single receptor and within ±10% for the average. Qualitative image noise characteristics in the resultant film images should be inversely related to incident exposure. Resultant optical density of each film should be within +/- 0.1 OD of the programmed value. Quantitative evaluation of the image properties on a computer workstation should verify a consistent average digital number independent of exposure, and a decrease in relative noise (increase in signal to noise) with increased exposure. The quantum-limited operation range is determined by plotting the standard deviation of the noise relative to the log incident exposure and determining the linear fit of the line with a slope of 0.5.

Variation in imaging plate response can occur with changes in beam quality caused by added tube filtration and/or patient attenuation, even with the same incident exposure [Huda, 95]. While it is suggested that the manufacturer recommended protocols be followed, the recommendations for added filtration made above would be contrary to the manufacturer protocol for Fuji systems. In the event that filtration is used, the recommended accuracy of the sensitivity value will likely not be met. Verification of accuracy without filtration, followed by re-calibration of the system with filtration is a recommended plan of action in this instance.

9.5.3 Receptor reproducibility, density uniformity and artifact analysis

Intrinsic and receptor to receptor uniformity are expected to be homogeneous and consistent. The tests in this section are contingent on a calibrated radiographic x-ray tube with reproducible output (±2% variation). *Each* cassette/phosphor plate in the inventory is centered to the x-ray beam and uniformly exposed over the entire plate at a long SID (~180 cm, to minimize heel effect variations and x-ray field shading) using 80 kVp and approximately 5 to 10 mR incident exposure. A reproducible geometry and plate orientation must be maintained.

For film output, optical densities are measured in the center of each quadrant of the film and in the center position to determine absolute density and spatial uniformity. Central film density is acceptable if within ±0.10 OD of the programmed optical density value (usually 1.20). Spatial uniformity is acceptable when all measured OD values are within 10% of the average (or programmed) OD. For soft-copy evaluation of the images on a workstation, the average digital value of each region of interest (ROI) should be within 10% of the global average. Standard deviation should also be similar in each of the 5 ROI's. Estimated incident exposure should be within ±10% (normalized for any measured exposure variation) for all phosphor plates in the inventory. (Note those specific setup requirements including kVp and added filtration are vendor specific.) All images should be examined for banding, black or white spots, and streaks. "Unique" artifacts are usually traced to the imaging plate in question, while artifacts appearing consistently on several or all images are likely due to the equipment (reader or writer components of the system). For artifacts identified to a specific imaging plate, initiate plate cleaning followed by primary erasure, and then retest. If the problem(s) still exist(s), the IP should be removed from service. In the case of a consistent variation in OD shading across the film, exposure of the same plate in 180° orientations will cancel any possible variations due to the x-ray tube heel effect. If the shading variation still persists after this action, the service engineer should implement a shading correction calibration.

For soft-copy image workstations, average digital number values using an analysis tool and region of interest (ROI) positioning across the active image area can be used in lieu of optical density measurements. Criteria should be the same as explained above. A subjective analysis of a contrast and brightness enhanced image should demonstrate a relatively uniform response if image tools are not available. Adjust the window width to a narrow setting (high contrast) and window level to approximately the mean value to demonstrate any severe non-uniformity.

9.5.4 Phosphor plate/cassette throughput

This test can be accomplished in conjunction with section 9.5.3. For systems with autoloaders, a total of 5-10 loaded cassettes of each specific cassette size should be processed as fast as possible, with the elapsed time beginning with the initiation of the readout cycle, and ending with the film (or digital image) appearing for image distribution. Extrapolation of the number of receptors processed per hour is straightforward. For systems with internal stackers and manual feed, ten cassettes should be fed into the reader without delay, and the elapsed time recorded as above. Throughput should be within 10% of the published specifications (unless other exceptions are made in the purchase agreement). For complete evaluation, each cassette size should be tested, as the readout time is typically dependent on the phosphor plate size. Pipelined processing realizes an increased throughput for several screens in the stacker, so the time for one processed image (display and film output) will be longer than the average time for a series of screens.

9.5.5 Laser beam function

Laser beam scan line integrity, beam jitter, signal dropout, and focus are evaluated in this test. Use a radiographic technique of ~80 kVp, 180 cm SID and mAs to deliver an incident exposure of ~5 mR. Place the steel ruler on a 35×43 cm (14" x 17") centered on the cassette and roughly (but not) *perpendicular* to the laser beam scan lines. Laser beam jitter is evaluated by examining the edge of the ruler on the image. Ruler edges should be straight and continuous over the full length of the film. Under- or overshoot of the scan lines in light to dark transitions along the ruler edge indicates a timing error, or laser beam modulation problem. View the image scan lines with a 10X (or greater magnification) loupe in various areas across the film to check for uniform spacing. The “stair-step” characteristics of the straight edge are normal. Scan line dropout is detectable as a lucent straight line in the open field and likely represents dust/dirt particles on the pickup light guide, a fairly common artifact. Image artifacts indicate sub-optimal performance and necessitate corrective action by service personnel.

9.5.6 Spatial Resolution

Spatial resolution tests include measurement of the central and peripheral limiting resolution of each image, for each plate size and plate type (standard and high resolution). Place the resolution test phantom(s) (e.g., lead bar square-wave test pattern) near parallel and near perpendicular to both the x (row) and y (column) directions in central and peripheral areas of each cassette (receptor) size. Expose the cassette to a relatively low beam energy (~60 kVp), 180 cm SID, and mAs to deliver ~5 mR (quantum mottle should be low). Use a readout/processing algorithm to enhance radiographic contrast without significant edge enhancement. For a CRT, zoom the digital image to the intrinsic resolution limit, and adjust window/level for best visualization of the object. Both central and peripheral resolution should indicate a response close to the maximum resolution specified for the individual combination of reading sampling rate and phosphor type. For a reader that scans and prints at 10 pixels per mm, the maximum resolution achievable is 5 lp/mm. Actual spatial resolution is also influenced by the phosphor plate type in use.) If the spatial resolution is more than 10% *less* than that indicated in the manufacturer's specifications for either the vertical or horizontal directions, corrective action should be initiated. On the other hand, it is important to recognize “spurious resolution”, where higher frequency patterns are visualized beyond a lower frequency bar pattern group which is blurred out, as a consequence of frequency aliasing. Measured resolution can exceed the theoretical sampled resolution limit if the test pattern is positioned at a diagonal to the x-y matrix. In this case, the “effective” sampling (pixel) pitch of the resolution pattern is made smaller by the sine of the angle (e.g., 0.707 for 45° angle), overestimating the actual limiting vertical or horizontal resolution. These tests are subjective and prone to error, but are usually sufficient for verification of appropriate spatial resolution response. A pre-sampled MTF analysis can be undertaken with the use of an edge or a slit pattern, a film microdensitometer or direct evaluation of the digital image, and Fourier analysis [Dobbins, 95; Fujita, 89].

9.5.7 Wire mesh test and resolution uniformity across the receptor

This test utilizes a screen-film contact test tool to verify focus over the total field of view of the phosphor receptor. One cassette of each size should be tested. Place the wire mesh test tool in direct contact with the PSP cassette, and expose the IP to a relatively low beam energy (~60 kVp), 180 cm SID, and mAs to deliver ~5 mR (quantum mottle should be low). Use a readout/processing algorithm that enhances radiographic contrast. The resultant image should be distortion free and sharp over the whole field of view. Distortions of the mesh pattern or areas of unsharpness that are unique to the individual phosphor plate indicate a PSP receptor that should be cleaned or removed from service. Repeatable distortions or unsharpness on images of different PSP receptors indicates an equipment malfunction.

9.5.8 Low Contrast Sensitivity/Detectability

Contrast resolution should be limited by quantum statistics (x-rays absorbed in the imaging plate) in a well-designed system. This test verifies the x-ray photon statistical limitations (quantum sink) over the exposure range commonly used for clinical x-ray imaging. Other noise sources, such as electronic, digitization, luminance, or fixed pattern noise should *not* limit the detection of a low contrast signal within the clinically used exposure range. A calibrated low contrast test object such as the Leeds phantom designed for computed radiography [McArdle, Leeds; Cowen, 93] or the UAB low contrast phantom [Wagner, 91]. The phantom should be imaged at the recommended beam energy using various incident exposures within the typical clinical range. For the Leeds phantom, 70 or 75 kVp is the calibration energy. With the UAB phantom, a range of peak operating potentials can be used, and the absolute contrast determined from a calibration chart dependent on the selected kVp and added copper filtration. In either situation, a standard clinical acquisition protocol should be used (e.g., contact imaging with a grid; PSP cassette placed in a table bucky, etc.). Three individual images are acquired with incident exposures of ~0.1 mR, ~1.0 mR and ~10 mR *to the phosphor plate.* Specific algorithms for contrast resolution should be used to process the plates. Contrast sensitivity should improve with increased exposure, related to reduced quantum noise. If not, other sources of noise and factors should be considered, such as reduced detection efficiency (e.g., standard versus high resolution imaging plates), fixed point noise (artifacts), excessive luminance or amplification noise, or x-ray/light scatter influence on the subject contrast, among other factors. The PSP system should deliver contrast sensitivity nearly equivalent to a screen-film detector with the same acquisition techniques (geometry, x-ray factors, grid, etc.). Request assistance of the service engineer to correct any significant problems that might arise. Once completed, the contrast sensitivity levels can serve as a basis for periodic QC tests and performance standards.

For systems with digital image analysis capabilities, a quantitative determination of the signal to noise ratio via region of interest (ROI) analysis (average signal divided by the RMS noise within a selected ROI) as a function of incident exposure should be considered. Contrast to noise ratio between low contrast objects in a contrast phantom (difference of average values divided by the RMS noise within the background ROI) provides a quantitative benchmark of PSP image receptor performance for a standardized acquisition technique. Establishment of baseline values allows an objective assessment of system performance by comparison of current and historical data.

9.5.9 Distance accuracy measurements and aspect ratio test

Distance accuracy is easily determined from a known sized object, the image reduction factor, and the measured distance on the film. For an image display workstation, pixel calibration should initially be performed for each IP/image matrix. The resolution test phantom image can be used to measure distance accuracy in the horizontal, vertical, or any oblique direction. For reduced size film images, the actual distance is the product of the measured distance and the image reduction factor. Comparison of the true distance to the actual measured distance should be within measurement error of 1 to 3 percent in both directions.

The aspect ratio test measures possible image distortion as the scanning galvanometer or polygonal mirror "ramps up" at the start of the line scan and stops at the end. Place several known square objects of high contrast (e.g., aluminum or copper filters) around the periphery of an IP. Using a standard radiographic technique, expose the plate to ~1 mR and process with a standard contrast sensitivity algorithm readout. Measure the resultant aspect ratio of the imaged objects on the film and/or with the digital calipers (if available) on the display workstation. For the latter, ensure that the pixel size is properly calibrated for a specific image receptor size. Verify that the x and y distances are within 1 to 3% of the absolute distance, and that the aspect ratio is equal to unity in the peripheral and central areas of the image without any spatially dependent variation.

9.5.10 Accuracy/thoroughness of erasure cycle

The PSP screens, if improperly or insufficiently erased, can potentially give rise to image artifacts that can mimic disease processes on subsequent image acquisitions. In particular, a receptor that is extremely overexposed might require several “erasures” before the residual latent image information is totally removed. To test the erasure capability, expose a PSP screen to an incident exposure of approximately 50 mR (80 kVp, 25 mAs, 180 cm, no filtration) with a centrally placed high contrast test object (e.g., resolution bar pattern) in contact. In some systems, if the exposure exceeds 200 mR, the plate will be recognized as “overexposed” and prohibited for immediate use or returned with a warning message. Process the plate using a standard clinical algorithm and *request return of the specific plate for those systems with internal stackers*. Re-expose the plate to a uniform incident exposure of about 1 mR (e.g., 80 kVp, 0.5 mAs @ 180 cm, no extra filtration) with a slightly smaller collimated area, and process using the same readout algorithm. Verify a lack of residual signal from the previous high exposure by looking for a ghost image of the resolution test pattern.

9.5.11 Image processing: LUT transforms and frequency enhancement

The intent of these tests are to verify the proper functioning of the various algorithms provided by the manufacturers regarding specific image processing algorithms and user selected adjustments for clinical applications. Specific changes to the parameters that determine the transformation of an acquired image from “raw” data to image data and verification of the outcomes are tested. On film-only systems, this requires the acquisition of several identical images on phosphor plates, which are then processed with specific changes (or specific exam selections) in the contrast levels, target optical densities, specific LUT curves, and frequency enhancement among others. This testing is simplified on systems that have an image display workstation and software that allows user selectable changes on a single image. Images of the low contrast phantom, an aluminum step wedge, and high resolution test phantom can provide a variety of image objects that clearly demonstrates the effects of the image processing parameters and their impact on image quality.

Review of clinical images and collaboration with the radiologists to tune the image display characteristics to their liking is important. PSP system specialists should be available after completion of the equipment installation to assist in the optimization of examination algorithms and to train technologists, physicists and radiologists in the operation of the PSP system, including minor algorithm adjustments by the physicist and/or interested QC technologist. Default processing variables/parameters should be verified with published standard values for all examination codes. Unique situations requiring specific settings such as a grid versus no grid examination should be doable for fine-tuning the system after confidence in the system is achieved.

10. ARTIFACTS

10.1 Image artifacts

Artifacts on images can originate from the hardware (e.g., x-ray system, grid, PSP reader, PSP receptor), software (e.g., glitches, algorithms), or the object (e.g., positioning, motion, etc.)[Oestmann, 91; Solomon, 91]. Hardware artifacts arise from the image plate, the image reader, the hardcopy printer or the processor. Most common are IP defects that are temporary, and are likely due to dust, dirt, or phantom (non-erased) images. These artifacts can be easily corrected by screen cleaning and/or plate erasure. Permanent IP artifacts can be traced to scratches or screen aging -- replacement will likely be necessary. The image reader can malfunction causing skipped scan lines, and/or distorted images. Laser power will diminish over time to a point beyond correction (lifetime is estimated to be years, depending on daily use), necessitating replacement of the laser subsystem. Dust particles on the galvanometer deflection mirror or on light collection device can be manifested as image dropout artifacts. Laser hardcopy printer misalignment and/or film conveyor malfunction can cause an uneven scan line distribution, image distortion, or shading, among a myriad of potential problems. Film processor artifacts should be considered as well.

10.2 Software artifacts

Improper selection of processing menus resulting in incorrect histogram normalization, dynamic range scaling, and output film density are the major causes of software artifacts. The histogram analysis function may incorrectly identify the pixel values of interest in the image. Causes include mis-positioning of the object, collimation detection errors that can occur in high scatter situations, and unusual anatomic variations that confuse the algorithms that identify the useful image information on the receptor.

10.3 Object artifacts

These artifacts usually arise due to object mis-positioning as described above, scan line interference patterns with the grid resulting in obvious moiré patterns, random drop-outs, or high pass frequency processing. If not properly adjusted, a "halo" effect could appear around the edges of objects by the unsharp masking technique. Backscatter can contribute significantly to contrast degradation when a substantial scattering volume is behind the cassette, possibly introducing phantom images such as the “tombstone” artifact [Tucker, 93] .

10.4 Film artifacts

Fogging, pressure marks, static electricity discharge, improper processing caused by inadequate or contaminated chemistry or inappropriate temperature levels of the developer/fixer, putting the film in upside down in the laser printer and other similar errors will result in the manifestation of artifacts attributed to film.

11. QUALITY CONTROL AND PERIODIC MAINTENANCE

Periodic quality control testing is necessary for checking system performance and maintaining optimum image quality. Daily, weekly, monthly and annual procedures are recommended as part of an ongoing QC program. In most cases, except for major problems and yearly tests, an assigned technologist can perform most of the tasks. A quality control phantom specifically designed for computed radiography is recommended as part of the purchase price of the system. In addition, automated QC methods for system evaluation, monitor maintenance/setup, and adjustments are becoming available, and should be requested from the manufacturers. Database management tools and spreadsheets are very powerful quantitative and graphical analyzers of pertinent system performance.

11.1 Daily (Technologist):

1. Inspect operational aspects of the system, including reader, ID terminals and viewing monitor
2. Check chemical levels of film processor
3. Create laser-generated sensitometry strip and measure film densities
4. Check film supply
5. Check chemical levels, chemical holding tanks and replenishment carriers on processor; add as needed

11.2 Weekly (Technologist):

1. Clean filters and vents on system and processor(s)
2. Erase all little-used, or non-circulating imaging plates in the inventory
3. If possible, create flash sensitometry strip for the processor only, and measure film densities
4. Verify monitor calibration for soft-copy review workstations (SMPTE pattern, contrast/brightness settings to visualize 0%-5% patch and 95%-100% patch simultaneously)
5. Inspect cassettes and imaging plates. Clean as necessary according to the manufacturers instructions
6. Acquire test phantom images and catalog results in computer database; check performance and take action when outside of pre-determined limits

11.3 Monthly (Technologist):

1. Do film processor maintenance, including chemistry replacement and full cleaning of tanks and racks.
2. Perform qualitative and quantitative QC phantom analysis (e.g., low contrast, spatial resolution, signal to noise ratio “spot-checks”
3. Review film retake rate, overview exposure indices, determine causes of unacceptable images

4. Review QC database; determine cause of problems and implement corrective action

11.4 Semi-Annually -- Annually (Physicist):

1. Perform linearity/sensitivity tests of imaging plate inventory.
2. Inspect/evaluate image quality; spot check image processing algorithms for appropriateness.
3. Undertake acceptance test procedures to verify and/or re-establish baseline values
4. Review retake activity, patient exposure trends, QC records and service history of the equipment.

In addition to the periodic testing, all inspections should be done on an "as needed" basis.

The designated QC technologist, physicist, and service personnel should participate in the preventive maintenance and quality control program. Invasive adjustments or corrections of the PSP system should be done only with “vendor-approved” personnel, and with the knowledge of the technologists, physicist, and other service personnel responsible for quality control. In addition to the periodic testing, all inspections should be done on an “as needed” basis, particularly for hardware/software changes and significant repairs/changes to the equipment.

12. CONCLUSIONS

Computed radiography using PSP receptors is the current state-of-the-art technology for digital image acquisition of projection images. This technology is becoming more widespread and clinically important, as it begins to replace the 100 year-old screen-film mainstay. While the paradigm of cassette-based x-ray imaging in terms of general radiographic technique and detector use is still intact, the considerable differences compared to screen-film imaging must be recognized. A large number of set-up parameters, inappropriate use of exposure menus, system hardware or software malfunctions, plate damage, excessive quantum mottle, and patient positioning details are among a host of potential issues that differ from screen-film experiences. Technologist and radiologist training which addresses initial orientation as well as continuing education on the technology of PSP radiography, including the unique attributes and image acquisition rules (collimation, auto-ranging, image processing) is extremely important. As proliferation of system types and manufacturers occur, specific system characteristics, controls and testing procedures must be considered, in addition to the “generic” operational aspects of photostimulable storage phosphors and photostimulated luminescence. The acceptance test and quality control procedures of a computed radiography system are reasonably straightforward and relatively easy to evaluate. A widespread use of such systems is anticipated in the near future, particularly in conjunction with imaging networks and digital image archiving. The technology continues to evolve, and the acceptance test and QC procedures must advance as well to ensure and maintain optimal image quality.

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Performance evaluation of computed radiography systems

Ehsan Samei[a)]
Department of Radiology, Duke University Medical Center, DUMC Box 3302,
Durham, North Carolina 27710

J. Anthony Seibert
Department of Radiology, UC Davis Medical Center, Sacramento, California 95817

Charles E. Willis
Department of Radiology, Baylor College of Medicine and Edward B. Singleton
Diagnostic Imaging Service, Texas Children's Hospital, Houston, Texas 77030

Michael J. Flynn
Department of Radiology, Henry Ford Health System, Detroit, Michigan 49202

Eugene Mah
Department of Radiology, Medical University of South Carolina, Charleston, South Carolina 29425

Kevin L. Junck
Department of Radiology, University of Alabama Medical Center, Birmingham, Alabama 35233

(Received 19 September 2000; accepted for publication 15 December 2000)

Recommended methods to test the performance of computed radiography (CR) digital radiographic systems have been recently developed by the AAPM Task Group No. 10. Included are tests for dark noise, uniformity, exposure response, laser beam function, spatial resolution, low-contrast resolution, spatial accuracy, erasure thoroughness, and throughput. The recommendations may be used for acceptance testing of new CR devices as well as routine performance evaluation checks of devices in clinical use. The purpose of this short communication is to provide a tabular summary of the tests recommended by the AAPM Task Group, delineate the technical aspects of the tests, suggest quantitative measures of the performance results, and recommend uniform quantitative criteria for the satisfactory performance of CR devices. The applicability of the acceptance criteria is verified by tests performed on CR systems in clinical use at five different institutions. This paper further clarifies the recommendations with respect to the beam filtration to be used for exposure calibration of the system, and the calibration of automatic exposure control systems. © *2001 American Association of Physicists in Medicine.* [DOI: 10.1118/1.1350586]

Key words: computed radiography, photostimulable phosphor radiography, acceptance testing, quality control, automatic exposure control

I. INTRODUCTION

Computed radiography (CR), scientifically known as photostimulable phosphor radiography, is a digital technology for the acquisition of radiographic images.[1,2] CR is the most common digital radiography modality in radiology departments today, with an estimated 7000 systems in use worldwide. The technology uses a conventional radiographic acquisition geometry to deposit x-ray energy in a photostimulable phosphor screen with delayed luminescence properties. After irradiation, the screen is stimulated by a scanning laser beam, to release the deposited energy in the form of visible light. The released photostimulated light is captured by a light detector, converted to digital signals, and registered with the location on the screen from which it has been released. The digital data are then postprocessed for appropriate presentation, and are sent to a hard-copy printer or a soft-copy display monitor for medical evaluation.

Upon installation and prior to clinical use, CR devices should be evaluated for satisfactory performance.[3,4] As of September 2000, there are five manufacturers of CR imaging devices, Agfa Medical Systems (Ridgefield Park, NJ), Fuji Medical Systems (Stamford, CT), Eastman Kodak Health Imaging (Rochester, NY), Konica Imaging Systems (Wayne, NJ), and Lumisys, Inc (Sunnyvale, CA). There are currently no industry standards for specifying the performance of these

TABLE I. CR systems evaluated in this study.

Manufacturer	CR device	Phosphor screen
Agfa	ADC-70 ADC-Compact ADC-Solo	MD-10
Fuji	FCR-9501 FCR-9501-HQ AC3-CS	ST-VA and ST-VN
	FCR-5000	ST-VN
Kodak	CR-400	GP-25 and HR
Lumisys	ACR-2000	MD-10

TABLE II. Testing devices required to perform the acceptance testing of a CR imaging device.

Testing device
Calibrated x-ray source
Calibrated hard/soft-copy display devices
Densitometer (if a hard-copy display is to be used)
Copper and aluminum filters
Calibrated ion chamber
Stand for the ion chamber
Screen cleaning solution and cloths
Two metric 30 cm steel rulers (for laser-beam function and spatial accuracy tests)
Three sector-type (0.4°) line-pair phantoms of up to 5 lp/mm frequency ($\geqslant$0.05 mm lead thickness)
Low-contrast phantom (e.g., Leeds TO.12)
Screen-contact wire-mesh pattern
Screen-contact fine wire-mesh pattern (e.g., mammography screen-film contact tool)
Small lead block ($>$3 mm thick)
Antiscatter grid (10:1 or 12:1, 103 ln/in.) (if the x-ray system does not have one)
Anthropomorphic phantoms (foot, hand, pelvis, chest, etc.)
Timer
Measuring tape
Flashlight
Role of masking tape

devices. The lack of uniformity in measurement procedures among different manufacturers has introduced ambiguity in the meaning of the system specifications. For example, different manufacturers calibrate the response of the system to a given exposure value using different beam qualities and report the response using indices which have different dependences on exposure. In a large medical institution in which CR devices of different kinds might be employed, it is important to assure that the patient images are acquired within a certain exposure range to prevent over- and underexposures. However, the lack of calibration uniformity makes the definition of the acceptable exposure ranges from the CR response values cumbersome.

In general, in order to achieve a consistent level of clinical performance, acceptance testing should utilize a uniform cross-platform methodology and uniform criteria so that the results of the tests can be correlated with clinical performance standards. Currently, Task Group No. 10 of the American Association of Physicists in Medicine (AAPM TG10)[5] is making an effort to provide a comprehensive standardized testing protocol for acceptance testing and quality control of CR systems. In this work, we have used the preliminary guidelines established by the AAPM Task Group to evaluate the performance of CR systems currently in use at different institutions represented by the co-authors. The paper provides a summary of the tests recommended by the AAPM Task Group, delineates the specific technical aspects of the tests, suggests quantitative measures of the performance results, and recommends uniform quantitative criteria for satisfactory performance. The recommendations provided in this paper are a first step toward meeting a need perceived by practicing clinical medical physicists for quantitative guidelines to be used in conjunction with AAPM TG10 recommended testing procedures.

TABLE III. Testing protocol and acceptance criteria for the dark noise test.

	Agfa	Fuji	Kodak	Lumisys
Exposure condition	No exposures. Erase a single screen and read it without exposing it.			
Screen processing	System diagnostics/flat field, speed class=200	Test/sensitivity (L=1), fixed EDR (S=10 000)	Pattern	Standard
Image postprocessing	None musica parameters=0.0 Sensitometry=linear	''Linear'' (GA=1.0, GT=A, RE=0.0)	''Raw data'' and ''no edge enhancement'' settings, window=512, level=exposure index	None
Measurements to be made	IgM, average pixel value (PV) and its standard deviation (PVSD), and scan average level (SAL) within 80% of the image	Avg. pixel value (PV) and its standard deviation (PVSD) within 80% of the image area	Exposure index (EI), average pixel value (PV), and its standard deviation (PVSD) within 80% of the image area	Average pixel value (PV) and standard deviation (PVSD) within 80% of the image area
Qualitative criteria for acceptance	Uniform image without any artifacts		Uniform without any artifacts except for collector profile bands in the screen-movement direction	Uniform image without any artifacts
Quantitative criteria for acceptance	IgM$<$0.28 SAL$<$130 PV$<$350 PVSD$<$5	PV$<$280[a] PVSD$<$4	$EI_{GP}<80$, $EI_{HR}<380$ $PV_{GP}<80$, $PV_{HR}<80$ PVSD$<$4	PV$>$3425 PVSD$<$4

[a] For those systems in which there is a direct relationship between PV and log(E). In the case of an inverse relationship, PV should be greater than 744.

TABLE IV. Testing protocol and acceptance criteria for uniformity (CR screen test).

	Agfa	Fuji	Kodak	Lumisys
Exposure condition	This test is applied to all the screens. Visually inspect the screens for physical defects. Verify that the cassette label matches the type of screen inside. Expose the screen to 10 mR (2.58×10^{-6} C/kg)[a] entrance exposure using 80 kVp, 0.5 mm Cu and 1 mm Al filtration, and 180 cm source-to-image distance (SID). If significant heel effect is present, test can be performed with two sequential half-exposures between which the orientation of the cassette is reversed.			
Screen processing	System diagnosis/flat field, speed class=200	Test/sensitivity (L=1), Semi EDR	Pattern	Standard
Image postprocessing	None, Musica parameters=0.0 Sensitometry=linear	''Linear'' (GA=1.0, GT=A, RE=0.0)	''Raw data'' and ''no edge enhancement'' settings, window=512, level=exposure index	None
Measurements to be made	Average pixel value (PV) and its standard deviation (PVSD) within 80% of the image area	Average pixel value (PV) and its standard deviation (PVSD) within 80% of the image area	Average pixel value (PV) and its standard deviation (PVSD) within 80% of the image area	Average pixel value (PV) and its standard deviation (PVSD) within 80% of the image area
	Screen-to-screen variations: Standard deviation of lgM (LMSDs), and mean and standard deviation of PV among screens (PVs and PVSDs)	*Screen-to-screen variations*: Standard deviation/mean sensitivity (SD/Ss) and standard deviation of average PV among screens (PVSDs)	*Screen-to-screen variations*: Standard deviation of exposure index among screens (EISDs)	*Screen-to-screen variations*: Standard deviation of average PV among screens (PVSDs)
Qualitative criteria for acceptance	Uniform image without any artifacts			
Quantitative criteria for acceptance	PVSD<25 (single screen) LMSDs<0.02 PVSDs<25	PVSD<20 (single screen) SD/Ss<5% PVSDs<20	PVSD<20 (single screen) EISDs<20	PVSD<20 (single screen) PVSDs<20

[a] Throughout these tables, for convenience, all exposures are expressed in units of mR (1 mR=2.58×10^{-7} C/kg).

II. METHODS AND RECOMMENDATIONS

As listed in Table I, CR devices in use at five different institutions from four major CR manufacturers were evaluated. The inventory of equipment used for testing is listed in Table II. Each system was evaluated for dark noise, screen uniformity, exposure indicator calibration, linearity and autoranging response, laser beam function, limiting resolution, noise and low-contrast resolution, spatial accuracy, erasure thoroughness, aliasing and grid response, and throughput.[6] Special attention was paid to applying a uniform testing protocol for different CR systems, following the recommendations of the AAPM TG10 as closely as practicable. The data from different institutions were collected and processed in a single database. Prior to or shortly after the evaluations, each system's performance was judged clinically acceptable by attending radiologists based on image quality of clinical images acquired with the system. Tables III–XIII tabulate the testing protocol and the acceptance criteria derived from the results. For a full description of the tests and the rationale for performing each test, the reader is advised to consult the AAPM TG10 report.

The quantitative acceptance criteria were established based on the results of the tests performed on the clinical systems and a uniform level of tolerance in system response across different systems. Table XIV tabulates the response tolerance levels based upon which the acceptance criteria were established. These levels were translated to system-specific parameters, as reported in Tables III–XIII, using the response relationships of the systems tabulated in Table XV. None of the clinically acceptable systems tested in this collaborative effort generated results beyond the established criteria. In most instances, the acceptance criteria were at least 20% beyond the extremes of the evaluation results, a reasonable margin considering that the evaluated systems were not operating at the borderline of clinical acceptability.

Several experimental precautions were observed in the evaluation of the systems. All the phosphor screens were cleaned and erased prior to executing the testing procedures. Consistent delay times between 1 to 15 min were observed between exposing and reading the screens. Care was taken to reduce backscattered radiation by utilizing cross-table exposures and significant interspace behind the screens. A large source-to-image distance (SID~180 cm) was used to minimize the heel effect. The ''raw'' signal values which were proportional to the log of the incident exposure without any postprocessing were used in the evaluations.

All exposures were measured in a consistent fashion: The collimators were set to expose the whole cassette with additional 7 cm margins on each side in the direction perpendicular to the anode–cathode axis. The ion chamber was then placed at the center of the beam at 2/3 of the SID. The exposure was measured in five consecutive exposures and the values averaged, E_1. Keeping the ion chamber at 2/3 SID, the chamber was shifted on the central axis perpendicu-

TABLE V. Testing protocol and acceptance criteria for exposure indicator calibration.

	Agfa	Fuji	Kodak	Lumisgys[b]
Recommended exposure condition[a]	Use multiple screens (at least three) of a given size/type. Expose the screens to approximately 1 mR (2.58×10^{-7} C/kg) enhance exposure using 80 kVp and 0.5 mm Cu/1 mm Al filtration. Screens should be read with a precise 10 min delay.			
Exposure condition (manufacturer specified[a])	Expose a screen to approximately 1 mR (2.58×10^{-7} C/kg) entrance exposure using 75 kVp and 1.5 mm Cu filtration. Screen should be read promptly.	Expose a screen to approximately 1 mR (2.58×10^{-7} C/kg) entrance exposure using 80 kVp without filtration. Screen should be read with a precise 10 min delay.	Expose a screen to approximately 1 mR (2.58×10^{-7} C/kg) entrance exposure using 80 kVp and 0.5 mm Cu/1 mm Al filtration. Screen should be read with a precise 15 min delay.	Expose a screen to approximately 8 mR (2.064×10^{-6} C/kg) entrance exposure using 80 kVp with 1 mm Cu filtration. Screen should be read promptly.
Screen processing	System diagnosis/flat field, speed class=200	Test/sensitivity ($L=1$), semi-EDR	Pattern	Standard
Image postprocessing	None, musica parameters=0.0	Irrelevant		None
Measurements to be made	IgM and IgM normalized to exactly 1 mR exposure to the screen ($\mathrm{IgM}_{1\,\mathrm{mR}}$) using $\mathrm{IgM}_{1\,\mathrm{mR}}=\mathrm{IgM}-\log(\mathrm{exposure})$, SAL and SAL normalized to exactly 1 mR exposure to the screen ($\mathrm{SAL}_{1\,\mathrm{mR}}$) using $\mathrm{SAL}_{1\,\mathrm{mR}}=\mathrm{SAL}/(\mathrm{exposure})^{0.5}$	Sensitivity and sensitivity normalized to exactly 1 mR exposure to the screen ($\mathrm{S}_{1\,\mathrm{mR}}$) using $\mathrm{S}_{1\,\mathrm{mR}}=\mathrm{S}$ exposure	Exposure index (EI) and exposure index normalized to exactly 1 mR exposure to the screen ($\mathrm{EI}_{1\,\mathrm{mR}}$) using $\mathrm{EI}_{1\,\mathrm{mR}}=\mathrm{EI}-1000\times\log(\mathrm{exposure})$	Mean pixel value (PV) within 80% of the image area normalized to exactly 1 mR ($\mathrm{PV}_{1\,\mathrm{mR}}$) or 8 mR ($\mathrm{PV}_{8\,\mathrm{mR}}$) exposure to the screen using $\mathrm{PV}_{1\,\mathrm{mR}}=\mathrm{PV}+1000\log(\mathrm{exposure})$ $\mathrm{PV}_{8\,\mathrm{mR}}=\mathrm{PV}+1000\log(\mathrm{exposure}/8)$
Qualitative criteria for acceptance	None			
Quantitative criteria for acceptance	$\mathrm{IgM}_{1\,\mathrm{mR}}-2.2<\pm0.045$ single screen $\mathrm{IgM}_{1\,\mathrm{mR}}-2.2<\pm0.023$ for all screens averaged $\mathrm{SAL}_{1\,\mathrm{mR}}-1192<\pm60$ single screen $\mathrm{SAL}_{1\,\mathrm{mR}}-1192<\pm30$ for all screens averaged	$\mathrm{S}_{1\,\mathrm{mR}}-200<\pm20$ single screen $\mathrm{S}_{1\,\mathrm{mR}}-200<\pm10$ for all screens averaged	$\mathrm{EI}_{1\,\mathrm{mR}}-2000<\pm45$ single screen $\mathrm{EI}_{1\,\mathrm{mR}}-2000<\pm23$ for all screens averaged	$\mathrm{Pv}_{8\,\mathrm{mR}}-600<\pm45$ single screen $\mathrm{PV}_{1\,\mathrm{mR}}-1505<\pm45$ single screen $\mathrm{PV}_{1\,\mathrm{mR}}-1505<\pm23$ for all screens averaged

[a] There is currently a strong consensus that CR systems should be calibrated with a standard filtered beam. Until such time as manufacturers change their recommendations, the calibration procedure can be performed both with the manufacturer-defined technique, to verify conformance with the manufacturer's specifications, and with 0.5 mm Cu/1 mm Al filtration and 10 min delay time, for benchmarking and constancy checks.

[b] The Lumisys ACR-2000 software did not make use of an exposure index at the time of testing. The system is calibrated to produce a pixel value of 600 in response to an 8 mR (2.064×10^{-6} C/kg) exposure to the screen.

lar to the anode–cathode axis toward the edge of the field just outside the useful beam area (the shadow of the ion chamber was still fully within the beam without projecting over the cassette area). The exposure was measured in five consecutive exposures again and the values were averaged, E_2. The chamber was kept at the second location during the tests for verification of the exposure values. The average exposure to the cassette in each single exposure was calculated as $(E_1/E_2)(2/3)^2$ (measured exposure).

III. DISCUSSION

To achieve a consistent level of clinical performance from CR systems, acceptance testing procedures should be performed according to a uniform cross-platform methodology. As in any medical physics survey, the performance evaluation of a CR system is also more definitive and objective when the evaluation is quantitative and the results are compared against specific quantitative acceptance criteria. In this work, an attempt was made to outline a cross-platform uniform methodology based on the guidelines being developed by the American Association of Physicists in Medicine Task Group 10. Furthermore, a first attempt was made to recommend quantitative acceptance criteria for satisfactory performance of a CR system based on the current state of practice. The criteria were established using uniform tolerance levels and test results acquired from CR systems in clinical use at five different institutions. The *user* specificity (as opposed to the conventional *manufacturer* specificity) of the acceptance criteria suggested in this paper was necessitated by the desired uniformity of the testing procedures. The criteria, however, do not guarantee optimal clinical performance, which may not be ascertained without comprehensive clinical trials.

TABLE VI. Testing protocol and acceptance criteria for linearity and autoranging response.[a]

	Agfa	Fuji	Kodak	Lumisys
Exposure condition	Use a single screen (multiple screens may also be used if the screen-to-screen variations in the previous test were found minimal). Expose the screen to approximately 0.1, 1, and 10 mR (2.58×10^{-8}, 2.58×10^{-7}, 2.58×10^{-6} C/kg) entrance exposures in a sequence of three exposure-reading cycles using 80 kVp, 0.5 mm Cu and 1 mm Al filtration, and 180 cm SID. Each time read the screen with a consistent delay time.			
Screen processing	System diagnosis/flat field, speed class=200	Test/ave 4.0 Semi-EDR and fixed EDR=200 repeat also with Test/contrast semi-EDR and fixed EDR=200	Pattern	Standard
Image postprocessing	None, musica parameters=0.0	''Linear'' (GA=1.0, GT=A, RE=0.0)	''Raw data'' and ''no edge enhancement'' settings	None
Measurements to be made	IgM, average pixel value (PV), and scan average level (SAL) within 80% of the image area. Slopes and correlation coefficients (CCs) of linear fits to log(SAL) vs log(*E*), PV vs log(*E*), and IgM vs log(*E*)	*For Semi EDR*, correlation coefficient (CC) of a linear fit to log(S) vs log (*E*) plot. *For fixed EDR*, avg. pixel value (PV) within 80% of the image area, slope and correlation coefficient (CC) of a linear fit to PV vs log(*E*)	Exposure index (EI) and avg. pixel value (PV) within 80% of the image area. Slope and correlation coefficient (CC) of a linear fit to EI vs log(*E*) and PV vs log (*E*) plots	Mean pixel value (PV) within 80% of the image area. Slope, intercept, and correlation coefficient (CC) of a linear fit to P vs log(*E*)
Qualitative criteria for acceptance	SAL vs exposure on a linear-log plot should result in a straight line	*For semi-EDR*, slope and correlation, sensitivity vs exposure on a log–log plot should result in a straight line. *For fixed EDR*, to PV vs exposure on a linear-log plot should result in a straight line	The plot of EI and PV vs exposure on a linear-log scale should result in straight lines	The plot of PV vs exposure on a linear-log scale should result in a straight line
Quantitative criteria for acceptance	$\mathrm{Slope}_{\mathrm{IgM}}-1<\pm0.1$ $\mathrm{Slope}_{\mathrm{SAL}}/0.5-0.1<\pm0.1$ $\mathrm{Slope}_{\mathrm{PV}}/1250-0.1<\pm0.1$ CCs>0.95	$\mathrm{Slope}_{\mathrm{s}}+1<\pm0.1$ $\mathrm{Slope}_{\mathrm{PV}}/256-1<\pm0.1$ (Ave 4)[b] $\mathrm{Slope}_{\mathrm{PV}}/511-1<\pm0.1$ (Con.)[b] CCs>0.95	$\mathrm{Slope}_{\mathrm{EI}}/1000-1<\pm0.1$ $\mathrm{Slope}_{\mathrm{PV}}/1000-0.1<\pm0.1$ CCs>0.95	Slopes/1000+1<±0.1 CCs>-0.95

[a] If this test is performed with hard copy prints, the relationship between the pixel value (PV) and optical density (OD) should be established beforehand using an electronic test pattern. The relationship between OD and PV should then be incorporated as a transformation in the quantitative analysis of the results.

[b] Note that in some Fuji systems, there is an inverse relationship between PV and log(*E*). For those systems, the polarity of the slope in these equations should be reversed.

TABLE VII. Testing protocol and acceptance criteria for the laser beam function.

	Agfa	Fuji	Kodak	Lumisys
Exposure condition	Place a steel ruler roughly perpendicular to the laser-scan direction on a screen. Expose the screen to about 5 mR (1.29×10^{-6} C/kg) entrance exposure using a 60 kVp beam without any filtration (SID=180 cm). Examine the edges of the ruler on the image for laser beam jitters using 10–20× magnification.			
Screen processing	System diagnosis/flat field, speed class=200	Test/sensitivity Semi-EDR	Pattern	Standard
Image postprocessing	None, musica parameters=0.0 sensitometry=linear	''Linear'' (GA=1.0, GT=A, RE=0.0)	''Raw data'' and ''no edge enhancement'' settings, window=512, level=exposure index	None
Measurements to be made	If any jitter is present, jitter dimension using workstation's ''measurement'' or ROI tool.			
Qualitative criteria for acceptance	Ruler edges should be straight and continuous without any under- or overshoot of the scan lines in light to dark transitions.			
Quantitative criteria for acceptance	There should not be more than occasional ±1 jitters.			

TABLE VIII. Testing protocol and acceptance criteria for the limiting resolution and resolution uniformity.[a]

	Agfa	Fuji	Kodak	Lumisys
Exposure condition	This test should be done for each type and size of the screens. Use a 60 kVp, unfiltered x-ray beam (SID=180 cm). Place three line-pair pattern devices on the cassette, two in orthogonal directions and one at 45°. Expose the screen with an exposure of about 5 mR (1.20×10^{-6} C/kg). Also acquire an image of a fine wire mesh (e.g., mammography screen–film contact test tool) in contact with the cassette to examine the consistency of the resolution response across the image.			
Screen processing	System diagnosis/flat field, speed class=200	Test/sensitivity semi-EDR	Pattern	Standard
Image postprocessing	None, musica parameters=0.0 sensitometry=linear	''Linear'' (GA=1.0, GT=A, RE=0.0)	''Raw data'' and ''no edge enhancement'' settings, window=512, level=exposure index	None
Measurements to be made	Maximum discernible spatial frequencies in the three directions (R_{hor}, R_{ver}, R_{45}) using a magnified (>10×), narrowly windowed presentation of the images			
Qualitative criteria for acceptance	The image of the wire mesh should be uniform without any blurring across the image			
Quantitative criteria for acceptance	$R_{\mathrm{hor}}/f_{\mathrm{Nyquist}}>0.9$ $R_{\mathrm{ver}}/f_{\mathrm{Nyquist}}>0.9$ $R_{45}/1.41\,f_{\mathrm{Nyquist}}>0.9$			

[a] Note that the spatial resolution response of a CR system can be more comprehensively evaluated by measuring the modulation transfer function (MTF) of the system (Refs. 7–9, 11–14).

TABLE IX. Testing protocol and acceptance criteria for noise and low-contrast resolution.[a]

	Agfa	Fuji	Kodak	Lumisys
Exposure condition	This test should be done for each type and size of the screens. A low-contrast resolution pattern is used (e.g., Leeds TO.12, 75 kVp beam with 1 mm of Cu filtration). For each screen type/size, acquire three images of the low-contrast phantom using 0.1, 1, and 10 mR (2.58×10^{-8}, 2.58×10^{-7}, 2.58×10^{-6} C/kg) exposures to the screens. Use a constant delay time of 10 min in reading each of the screens.			
Screen processing	System diagnosis/flat field, speed class=200	Test/contrast Semi-EDR	Pattern	Standard
Image postprocessing	None, musica parameters=0.0 Sensitometry=linear	''Linear'' (GA=1.0, GT=A, RE=0.0)	''Raw data'' and ''no edge enhancement'' settings, window=512, level=4096−EI (for GP screens) or level=3796−EI (for HR screens)	None
Measurements to be made	Minimum discernible contrast for each object size (contrast detail threshold), Standard deviation of pixel value (PVSD) within a fixed (size and location) small region of the images, correlation coefficient (CC) of the linear fit to log(PVSD) vs log(E).[b]			
Qualitative criteria for acceptance	Contrast-detail threshold should be proportionately lower at higher exposures.		Contrast-detail threshold should be proportionately lower at higher exposures, with higher contrast thresholds for standard-resolution screens.	Contrast-detail threshold should be proportionately lower at higher exposures.
Quantitative criteria for acceptance	CC>0.95[b]			

[a] Note that the noise response of a CR system can be more comprehensively evaluated by measuring the noise power spectrum (NPS) and the detective quantum efficiency (DQE) of the system at different exposure levels (Refs. 8 and 9, 11–14).

[b] The quantitative evaluation is more valid with uniform images acquired for the linearity test (Table VI) because of the absence of scattering material in the beam. The expected quantitative response is based on the assumption of a logarithmic relationship between pixel value and exposure (Table XV).

TABLE X. Testing protocol and acceptance criteria for spatial accuracy.

	Agfa	Fuji	Kodak	Lumisys
Exposure condition	Place a regular wire-mesh screen–film contact test tool over cassette. Expose the cassette to about 5 mR (1.29×10^{-6} C/kg) entrance exposure using a 60 kVp beam without any filtration (SID=180 cm). Repeat the acquisition with two steel rulers in the vertical and the horizontal directions.			
Screen processing	System diagnosis/flat field, speed class=200	Test/contrast Semi-EDR	Pattern	Standard
Image postprocessing	None musica parameters=0.0	''Linear'' (GA=1.0, GT=A, RE=0.0)	''Raw data'' and ''no edge enhancement'' settings, window=512, level=EI	None
Measurements to be made	Distances in the orthogonal directions (15 cm minimum length) measured using the measurement tool of the workstation.[a]			
Qualitative criteria for acceptance	Grid pattern spacing should be uniform without any distortion across the image.			
Quantitative criteria acceptance	Measured distance should be within 2% of the actual values.			

[a] Alternatively, length measurements can be made on a hard-copy film printed in ''true-size.''

TABLE XI. Testing protocol and acceptance criteria for erasure thoroughness.

	Agfa	Fuji	Kodak	Lumisys
Exposure condition	Place a thick lead block at the center of a 14×17 cassette and expose the screen to about 50 mR (1.29×10^{-5} C/kg) using a 60 kVp x-ray beam without any filtration (SID=180 cm). Read the screen, and expose it a second time to 1 mR (2.58×10^{-7} C/kg) entrance exposure without the lead object using the same beam quality collimated in by about 5 cm on each side of the screen. For a quantitative test *re-read* the screen after the second exposure *without exposing it*.			
Screen processing	System diagnosis/flat field, speed class=200	Test/sensitivity semi-EDR	Pattern	Standard
Image postprocessing	None, musica parameters=0.0 Sensitometry=linear Window setting default or equivalent to 1 log(exposure) unit	''Linear'' (GA=1.0, GT=A, RE=0.0) Window setting default or equivalent to 1 log(exposure) unit	''Raw data'' and ''No edge enhancement'' settings, level=EI, window setting default or equivalent to 1 log(exposure) unit	Window setting default or equivalent to 1 log(exposure) unit
Measurements to be made	IgM, average pixel value (PV) and its standard deviation (PVSD), and scan average level (SAL) within 80% of the reread/unexposed image	Avg. pixel value (PV) and its standard deviation (PVSD) within 80% of the reread/unexposed image	Exposure index (EI), average pixel Value (PV), and its standard deviation (PVSD) within 80% of the reread/unexposed image	Average pixel value (PV) and standard deviation (PVSD) within 80% of the reread/unexposed image
Qualitative criteria for acceptance	Absence of a ghost image of the lead block from the first exposure in the reexposed image.[a,b]			
Quantitative criteria for acceptance	IgM=0.28 SAL<130 PV<630 PVSD<5	PV<280[c] PVSD<4	$\mathrm{EI}_{\mathrm{GP}}<80$, $\mathrm{EI}_{\mathrm{HR}}<380$ $\mathrm{PV}_{\mathrm{GP}}<80$, $\mathrm{PV}_{\mathrm{HR}}<80$ PVSD<4	PV>3425 PVSD<4

[a] In our tests on the ACR-2000 system, the length of the standard erasure cycle was sufficient for exposures up to 32 mR (8.256×10^{-6} C/kg). Higher exposures to the screen required an additional erasure cycle for complete screen erasure.

[b] Note that erasure time in some systems (e.g., Agfa) is configurable on an exam-by-exam basis.

[c] For those systems in which there is an direct relationship between PV and log(*E*). In the case of inverse relationship, PV should be greater than 744.

TABLE XII. Testing protocol and acceptance criteria for the aliasing/grid response.

	Agfa	Fuji	Kodak	Lumisys
Exposure condition	This test should be performed for each type and size of screens that will be commonly used. Place the screen in a bucky that contains an antiscatter grid so that the grid lines are parallel to the laser-scan direction. Alternatively, a grid may be placed directly on the screen. Make sure the grid movement is disabled. Expose the screen to 1 mR (2.58×10^{-7} C/kg) using an 80 kVp beam filtered with 0.5 mm Cu/1 mm Al filter and a SID according to the specification of the grid. Repeat, placing the screen perpendicular to the laser-scan direction. Repeat the exposures with a moving grid.			
Screen processing	System diagnosis/flat field, Speed class=200	Test/contrast semi-EDR	Pattern	Standard
Image postprocessing	None, musica parameters=0.0 sensitometry=linear A narrow window setting	''Linear'' (GA=1.0, GT=A, RE=0.0) A narrow window setting	''Raw data'' and ''no edge enhancement'' settings, level=EI, a narrow window setting	None
Measurements to be made	None			
Qualitative criteria for acceptance	Moiré pattern should not be present when the grid lines are perpendicular to the laser-scan direction. For moving grids, no moiré pattern should be apparent when the screen is placed in either direction.[a]			
Quantitative criteria for acceptance	None			

[a] Moiré patterns caused by display sampling (not addressed in this protocol) can be distinguished by their changing behavior with changing the magnification of the image on the soft-copy display device.

In light of this limitation, the recommended quantitative criteria should only be considered as helpful suggestions that require further clinical validation in the future.

Another limitation of the current work is the fact that many of the evaluation procedures were not fully quantitative or can be influenced by the subjectivity of the examiner. The evaluations of limiting resolution and noise performance (Tables VIII and IX) are two important examples. The resolution tests used do not evaluate the system transfer characteristics but only establish that some modulation can be detected at the limiting frequency. The noise tests subjectively evaluate the contrast-detail characteristics of the system, and the proposed quantitative test does not evaluate the spatial characteristics of image noise. Ideally, the resolution and noise characteristics of a CR system should be more objectively evaluated by measuring the frequency-dependent modulation transfer function, the noise power spectrum, and the detective quantum efficiency of these systems. A number of investigators have been able to successfully and reproducibly characterize the resolution and noise performance of CR systems using these indices,[11–13] and more recently reproducible measurements have been made in the field.[7,14] However, a routine implementation of these measurements awaits further standardization of measurement methods, and the de-

TABLE XIII. Testing protocol and acceptance criteria for the throughput.

	Agfa	Fuji	Kodak	Lumisys
Exposure condition	Expose 4 screens to 80 kVp, 2 mR (5.18×10^{-7} C/kg). Process the screens sequentially without delay.[a]			
Screen processing	System diagnosis/flat field, speed class=200	Test/contrast semi-EDR	Pattern	Standard
Image postprocessing	musica parameters typical of those in clinical usage	Irrelevant		None
Measurements to be made	Time interval (t, in minutes) between putting the first screen in and the last image appearing on the CR viewing station[b] Throughput (screens/h)=$60\times4/t$			
Qualitative criteria for acceptance	None			
Quantitative criteria for acceptance	Throughput should be within 10% of the system's specifications.			

[a] The test can be performed multiple times with different size cassettes.
[b] Contribution of the network configuration is not considered.

TABLE XIV. The CR response tolerance levels based upon which the uniform quantitative acceptance criteria were derived (using the equations tabulated in Table XV). All signal levels and standard deviations are expressed in terms of corresponding exposure (E) values deduced from those quantities.

Characteristics	Quantity of interest	Acceptable tolerance
Dark noise	Average signal and its standard deviation within 80% of the image area	$E<0.012$ mR ($E<3.1\times10^{-9}$ C/kg) $\sigma_E/E<1\%$
Uniformity	Signal standard deviation within 80% of the image area, and the standard deviation of the average screen signal among screens	$\sigma_E<5\%$
Exposure calibration	The exposure indicator response (expressed in terms of exposure) to 1 mR (2.58×10^{-7} C/kg) entrance exposure	$E_{\text{measured}}-1<\pm10\%$
Linearity and autoranging	The slope of the system response (expressed in terms of logarithm of exposure) vs logarithm of actual exposure	Slope $-1<\pm10\%$ Correlation coefficient >0.95
Laser beam function	Jitter dimension in pixels	Occasional jitters $<\pm1$ pixel
Limiting resolution	Maximum discernible spatial frequencies of a high-contrast line-pair pattern in two orthogonal and 45° angle directions	$R_{\text{hor}}/f_{\text{Nyquist}}>0.9$ $R_{\text{ver}}/f_{\text{Nyquist}}>0.9$ $R_{45}/1.41f_{\text{Nyquist}}>0.9$
Noise and low-contrast resolution	A linear fit of system noise (expressed in terms of logarithm of corresponding σ_E/E) to logarithm of actual exposure	Correlation coefficient >0.95
Spatial accuracy	The difference between the measured (d_m) and actual distances (d_0) in the orthogonal directions	$(d_m-d_0)/d_0<2\%$
Erasure thoroughness	Average signal and its standard deviation within 80% of the reread/unexposed image	$E<0.012$ mR ($E<3.1\times10^{-9}$ C/kg) $\sigma_E/E<1\%$
Aliasing/grid response	No quantitative tolerance levels	
Throughput	Measured throughput in screens per hours (T_m) and the specified throughput (T_0)	$(T_0-T_m)/T_0<10\%$

velopment of automated commercial QC products.

In this study, the exposures for quantitative measurements were made with 0.5 mm copper and 1 mm additive aluminum filtration in the beam. The use of filtration was based on prior studies[10,15,16] indicating that the use of 0.5 mm Cu filter minimizes the dependency of the results on the kVp inaccuracy and on the variations in the x-ray generator type, as the filter attenuates the ''soft'' portion of the spectrum, predominantly responsible for tube-to-tube variations (Fig. 1). The use of this filtration also makes the spectrum a more accurate representative of primary x rays incident on the detector in clinical situations (Fig. 2). The additional post-Cu, 1-mm-thick Al filter is used to attenuate any potential secondary low-energy x rays generated in the Cu filter. The use of 0.5 mm Cu/1 mm Al filtration, therefore, is advised for checking the consistency of the response in the acceptance testing and annual compliance inspections of CR systems.

This paper outlines the steps for only the *physical* evaluation of CR systems. In a newly installed system, after completion of the physical acceptance testing and prior to a full clinical utilization, the system should also be evaluated for its *clinical* performance. The appearance of CR images may vary as a function of radiographic technique factors, the specific recipe of image processing parameters applied to the images, and the type and calibration of the display media. The default image processing parameters of the system for various anatomical sites and views (e.g., chest PA, chest lateral, chest portable, knee, etc.) should be tested and customized by the application specialists of the manufacturer with assistance of the diagnostic medical physicist and under the direction of the radiologist who is ultimately responsible for the clinical acceptability of the images. Using radiographic techniques provided by the manufacturer, images of various anthropomorphic phantoms should be acquired with various combinations of collimation and positioning, utilizing the appropriate prescribed anatomical menus of the system. In each case, the proper processing of the image and the absence of unexpected positioning and collimation errors should be verified. Attending radiologists should be consulted for acceptability of the image processing parameters for each anatomical menu. Since standard anthropomorphic phantoms have a limited ability to represent human anatomy and patient-to-patient variations, the clinical evaluation and cus-

TABLE XV. The relationship between exposure and pixel value/exposure indicator responses of various CR systems. The relationships which were provided by the manufacturers or derived from their literature, were verified against experimental measurements at 80 kVp with 0.5 mm Cu/1 mm Al filtration. In these relationships, PV is the pixel value, E is the exposure in mR, B is the speed class, and L is the latitude of the system.

	Agfa	Fuji	Kodak	Lumisys
Exposure indicator quantities	IgM and scan average level (SAL)	Sensitivity (S)	Expsoure index (EI)	None
Exposure indicator relationship	$\mathrm{SAL}=90\sqrt{0.877cBE}$ $\mathrm{IgM}=2\log(\mathrm{SAL})-3.9478$ $=\log(cBE)-0.0963$ $c=1.0$ *for* MD10 *screens*	$S=200/E$	$\mathrm{EI}=1000\log(E)+2000$	None
Pixel value relationships	$\mathrm{PV}=2499\log(\mathrm{SAL})-4933$ $=1250\log(cBE)-121$[a] $c=1.0$ *for* MD10 *screens*	$\mathrm{PV}=(1024/L)$ $\times(\log E+\log(S/200))$ $+511$[b]	$\mathrm{PV}=1000\log(E)+c_0$ $c_0=2000$ *for GP screens* $c_0=1700$ *for HR screens*	$\mathrm{PV}=1000\log(32/E)$
Exposure/reading condition	75 kVp and 1.5 mm Cu filtration, no reading delay	80 kVp without filtration, 10 min reading delay	80 kVp and 0.5 mm Cu/1 mm Al filtration, 15 min reading delay	80 kVp with 1 mm Cu filtration, no reading delay

[a] Using a 12 bit, linear log(E) data transfer from Agfa QC workstation.

[b] Assuming a direct relationship between exposure and pixel value.

tomization of the image processing parameters should include actual clinical images.

Care should be taken that in the validation of the system settings, all examinations performed at the facility are represented. The final customized image processing parameters and system settings for different anatomical menus should be loaded into all units from the same manufacturer in place at the institution or associated medical facilities, where the same exam may be performed on different machines, to assure consistency of image presentations. They should also be documented in a list for future reference.

Patient dose is one of the important implementation considerations in the use of CR in a traditional film-based radiology department.[17] In screen–film radiography, film density is a direct indicator of patient dose. In CR, however, because of the dissociation of the detection and the display functions of the imaging system, optical density can no longer be used as an indicator of the patient dose. In reading a CR screen, almost all CR systems provide an index that reflects the average exposure received by the screen during the image acquisition (Table XV). This exposure indicator can be used to define and monitor patient exposures. Based on the manufacturer's recommendations regarding the intrinsic speed of the system and on the applicable standards of practice, the user should establish, monitor, and enforce the acceptable range of exposure indicator values for the clinical operation in the facility. Note, however, that if a filtration other than that suggested by the manufacturer is used for the exposure calibration of the CR system, as suggested previously, the accepted range of exposure indicator values should be derived based on the comparative results of the two filtration conditions.

Automatic exposure control (AEC) is the primary means for controlling patient exposure in general radiography practice. For screen–film systems, the AEC is calibrated for consistency in optical density resultant from varying exposure techniques. Because of the dissimilarity between x-ray absorption characteristics and radiographic speed of CR and conventional screen–film radiography systems, an AEC calibrated for screen–film radiography is unlikely to be suitable for CR usage.[18] For CR usage, the AEC can be calibrated using an approach similar to that for screen–film imaging using the exposure indicator value of the system as the target variable to be controlled. The AEC should be adjusted to result an exposure indicator value within a narrow acceptable range (10%–15%) when the kVp or phantom thickness is varied within clinical operational limits. It may also be set to provide a constant change in the exposure indicator value

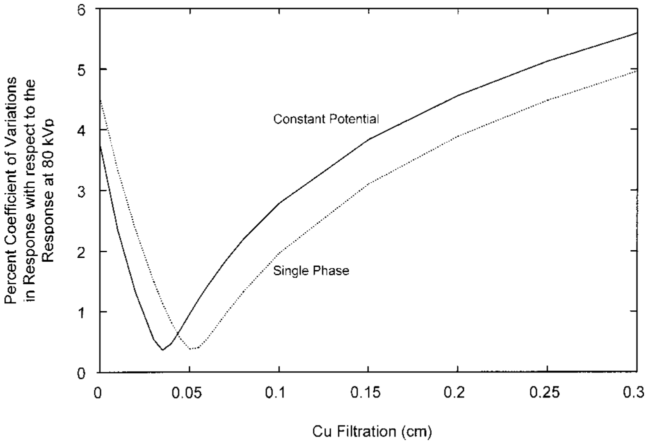

FIG. 1. The relative variation in the response of a CR system (signal per unit exposure), where the energy of the beam is varied within 80 kVp±10% range, as a function of Cu filtration in the beam for both single phase and high-frequency/constant-potential generator x-ray systems (12° anode angle, 2.6 mm intrinsic Al filtration). The data were generated by a computational model for simulation of the x-ray spectra, filter attenuation, and absorption characteristics of $\mathrm{BaFBr_{0.85}I_{0.15}}$:Eu phosphor screens (98 mg/cm^2 phosphor coating weight). The model accuracy has been previously verified against experimental measurements (Refs. 8, 10, 14). Note that Agfa CR systems use a slightly different phosphor material ($\mathrm{Ba_{0.86}Sr_{0.14}F_{1.1}Br_{0.84}I_{0.06}}$) than the one modeled here.

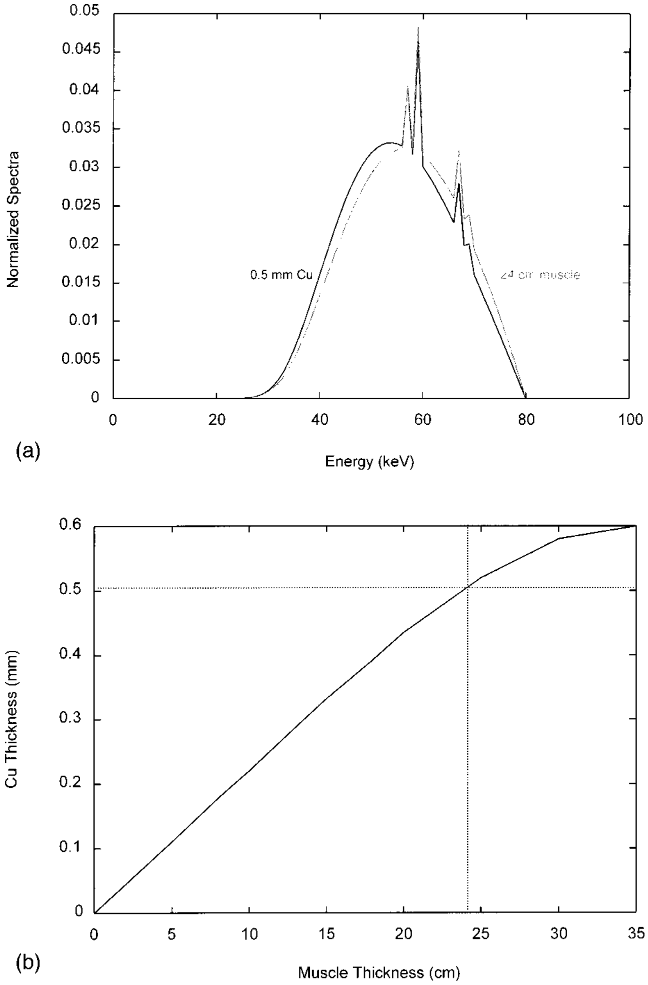

FIG. 2. (a) The model-calculated primary x-ray spectra emerging from a 0.5 mm Cu filter and 24 cm tissue-equivalent material. The spectra were normalized to have the same total area. b) The model-calculated equivalency of the CR signal per unit exposure for various Cu and tissue-equivalent material (see Fig. 1 caption).

when plus or minus density steps are applied. Because the CR exposure indicator is a quantity derived from analysis of the image histogram, care must be exercised in the selection of phantoms and processing menus. The phantoms should produce image histograms representative of clinical images, not a very trivial requirement. Otherwise, inaccurate exposure indicator values may result, leading to faulty AEC calibration. Further work on AEC calibration methodology for CR is warranted.

IV. CONCLUSIONS

The methods and acceptance criteria for the performance evaluation of CR systems were presented in a comprehensive tabular form for imaging systems from four major CR manufacturers. The materials can be used as a handbook for acceptance testing and quality control inspection of CR systems to assure the consistency and reliability of their clinical operation.

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15. APPENDICES

15.1 Appendix 1: General Information

Manufacturers of PSP system products; points of contact

Addresses of North American operations and international headquarters are probably sufficient.

- Fuji Photo Film.
- Eastman Kodak
- Agfa
- Other manufacturers selling the major manufacturers of PSP system products

Systems (e.g. standard readers; remote readers; hardcopy only; hardcopy/softcopy; dedicated chest, etc.) and interfaces

Specific system characteristics (e.g., demographics, processing parameter description, etc.)

Phantoms

Commercial and vendor supplied imaging phantoms

Sample acceptance testing and quality control forms

Ehsan Samei-- Excel spreadsheet to be included, which represents a generic / specific emulation of the tasks outlined in the acceptance test procedures.

15.2 Appendix 2

Fuji Photo Film Company

Introduction

Computed radiography (CR or PSP) systems manufactured by Fuji Photo Film Company, Limited, have been in operation since the early 1980's. Several generations of equipment have evolved since the initial clinical systems. As of 1996, Fuji has several PSP system models in clinical use, including the 901, 7000, AC-1, AC-1 plus, AC-2, AC-3, the 9000, 9000HQ, 9501 dedicated chest imaging device, and 9502 table model. In addition, there are several manufacturers that sell the Fuji product, including Philips, Siemens, Toshiba, DuPont (now Sterling Diagnostics), and General Electric. These vendors often characterize the Fuji system with alternate algorithm names and parameter values than those described in this appendix. The reader is advised to consult the specific operations manuals and to be aware of these nomenclature and value transformations.

Functional Specifications

Basic specifications of Fuji PSP radiography products in current clinical practice are listed in table A2-I. Specific capabilities and specialized equipment are not listed.

TABLE A2-I. Specifications of computed radiography systems manufactured by Fuji Photo Film Company

Plate size / Type	Digital Matrix	Read Sampling rate	Plates Per Hour (approx)*			
			AC-1 Plus	**AC-3**	**9000**	**5000**
8" × 10" ST	2000 × 2510	10 pixel / mm	N/A	90	120	
10" × 12" ST	1760 × 2010	6.7	38	80	125	
14" × 14" ST	1760 × 1760	5	40	70	110	
14" × 17" ST	1760 × 2140	5	36	65	95	
AC-1 8"×10" logical reading on 10"×12"	1330 × 1670	6.7	36	N/A	N/A	

*In the case of a direct connection to a Fuji FL-IMD laser imager.
The "HQ" option available on CR reader systems can allow read sampling rate up to 10 pixel/mm for all size imaging plates. Consult the system specification brochures for further information.
Note: N/A: not available.

Inventory

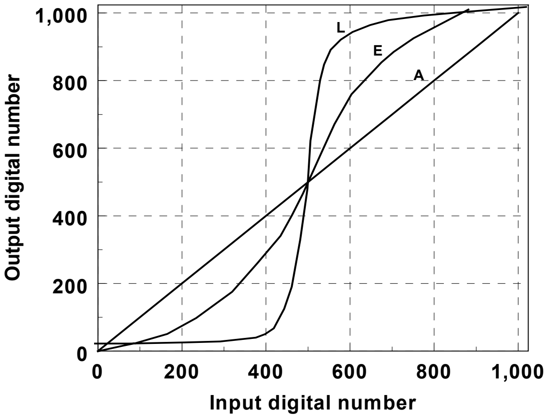
With many products and options for each particular system, the inventory list varies considerably. A list of the components delivered with a particular system can be requested from a local Fuji Medical Systems representative for each installation plan.

System functional overview

System functions of the Fuji AC-3 and 9000 system are described in this appendix. The Fuji PSP radiography system currently uses a photostimulable storage phosphor plate comprised of a barium fluorobromide/iodide ($BaFBr_{0.85}I_{0.15}$) compound with an activator (europium) [A1]. In November, 1997, ST-VN imaging plates were released (where "V" indicates the generation and "N" indicates the latest IP generation) of ~210 μm thickness, designed for lower energy diode lasers (680 nm). A high-resolution plate, HR-V, with reduced phosphor thickness (~120 μm) is also available for applications in mammography and extremity examinations. Earlier generation plates (ST III-N and ST-III) were designed for Helium-Neon lasers of higher energy. These plates should not be used with newer diode laser PSP readers, although ST-V generation plates can be used with the HeNe laser systems. Scanning provides a digital image matrix of approximately 1800 × 2100 pixels with 1024 gray levels (10 bits) when operated in the standard resolution mode. The digital output represents the *pre-processed* data. Some older Fuji PSP systems perform a non-destructive, low energy pre-scan of the latent image to determine the minimum and maximum range of the useful signal (e.g., the Fuji 7000 PSP reader) [A1]. At this writing, current generation scanners (Fuji AC-3 and 9000 PSP readers) digitize the total x-ray induced signal over a range of incident exposures from 0.01 to 100 mR (2.58×10^{-9} to 2.58×10^{-5} Coul/kg air). Prior to the ADC, a logarithmic amplifier is employed. A 12 bit ADC produces 11 bits of effective quantization levels prior to normalization of the image 10 bit depth.

Subsequent pre-processing of the data includes an information finding procedure called the exposure data recognizer (EDR) to correctly identify the signals that make up the clinical image (e.g., areas outside the collimated region and non-exposed areas of the detector must be excluded). An algorithm determines the amount of amplification (or de-amplification) required for appropriate signal scaling. The *system sensitivity* number -- a value proportional to the amount of signal amplification required (and thus inversely proportional to the incident exposure on the detector) -- is recorded on the image during readout and image display.

Conversion of the properly scaled (amplified or de-amplified) digital numbers occurs via a look-up-table (LUT) transformation examples of which are shown in Figure A2-__. Curve “L”, for example, re-maps the digital values over a small range, rendering extremely high contrast for small differences in signal variation and providing high radiographic contrast. This is specially optimized for display of digital subtraction angiography images acquired with PSP imaging plates. Curve “E” produces less radiographic contrast but is closer to that of a screen-film system, and curve “A” does not change the input signal variations at all, resulting in a very flat, low contrast and wide exposure latitude image. (Curve “A” is typically used in conjunction with frequency processing and edge enhancement.) These and other curves are pre-programmed in the PSP system and are associated with given examination types.



FigureA2-2. Transformation curves are programmed into the Fuji system to convert the digital values proportional to exposure into variations in optical density, in order to create images similar to film, or user preference. Three look-up-transformation curves are shown out of at least16 selections. In addition, a capability to adjust each curve is possible with the gradation processing algorithms.

Reading and Processing

The specific readout parameters for the Fuji PSP system and representative manufacturers of the Fuji product utilize similar, but not always the same readout parameter values. Each film generated from an imaging plate has several parameters. These include exposure latitude (L), system sensitivity (S), contrast and brightness adjustments (C), grayscale re-mapping algorithm (G), frequency processing setting (R), and dynamic range control settings (D). Patient demographics, time and date, image reversal indicator, image reduction factor, system readout (EDR) method (automatic -- A; semi-automatic --S; fixed --F), and others are specified in the applications manual. A brief review of these parameters is illustrated in figure A2-3. Consultation of the specific user manual is required to determine the meanings of the values presented.

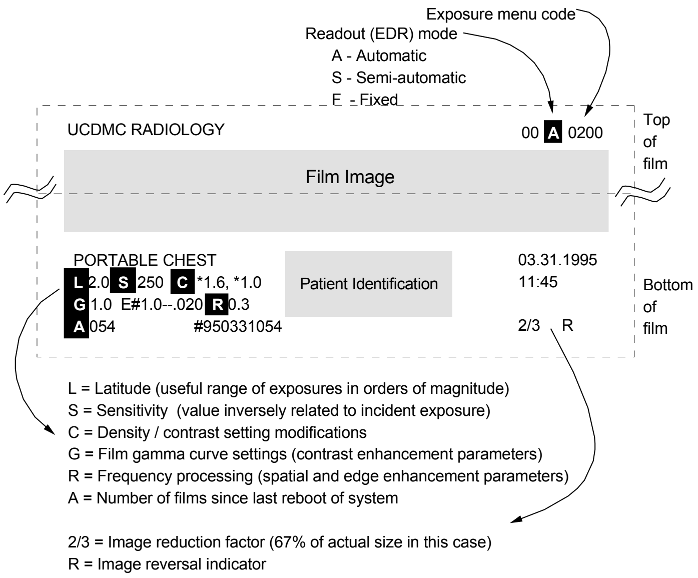

Exposure menu code
Readout (EDR) mode
A - Automatic
S - Semi-automatic
F - Fixed
UCDMC RADIOLOGY
00 A 0200
Top of film
Film Image
PORTABLE CHEST
L 2.0 S 250 C *1.6, *1.0
G 1.0 E#1.0--.020 R 0.3
A 054 #950331054
Patient Identification
03.31.1995
11:45
2/3 R
Bottom of film
L = Latitude (useful range of exposures in orders of magnitude)
S = Sensitivity (value inversely related to incident exposure)
C = Density / contrast setting modifications
G = Film gamma curve settings (contrast enhancement parameters)
R = Frequency processing (spatial and edge enhancement parameters)
A = Number of films since last reboot of system
2/3 = Image reduction factor (67% of actual size in this case)
R = Image reversal indicator

Figure A2-3. Film demographics for the Fuji AC-1 system is illustrated. There are 3 separate values for the G and R parameters, which describe the characteristic curve transformation and frequency enhancement settings, respectively. Specific information is published in the system applications manual.

Reading and processing the stimulated luminescence signals

Histogram analysis is used to define the wanted versus unwanted signals in a scanned image plate for a particular incident exposure and examination type. As the linear exposure latitude for the imaging plate is very wide, a variable reading sensitivity (sensitivity number, S) is necessary to map the stimulated luminescence of the imaging plate to a range of output digital numbers within a 10 bit range (1024 discrete graylevels). A second parameter, the latitude (L), indicates the range of stimulated luminescence (minimum to maximum) that will be included in the output digital number range, and is inversely proportional to a gain applied to the pre-processed data as determined by the EDR. Since the density range and contrast of a given x-ray examination has distinctive character, algorithms are tuned to analyze the histogram in an equally distinctive manner. There are three user selectable modes that can be applied to the histogram to optimize the resultant image.

In the ***Automatic*** mode, the PSP reader determines the latitude as well as the minimum and maximum stimulated luminescence values of the information extracted by the EDR process. On older systems (e.g., the 7000 series reader) a low energy, coarsely sampled laser pre-scan of the imaging plate is used to determine the location and collimation of the exposure field(s). The algorithm, PRIEF, (Pattern Recognizers for IRIS of Exposure Field) [] generates a histogram and determines the maximum and minimum intensities of the effective image data. From this information, the photomultiplier tube sensitivity and amplifier gain is set to match the output signal range for optimal digitization by the ADC. A subsequent high-resolution scan is then obtained. On the newer systems (e.g., 9000 series systems), the imaging plate is scanned directly using a combination of an analog logarithmic amplifier and a 12 bit (4096 graylevels) ADC encompassing the full dynamic range of the stimulated luminescence intensity at a fixed PMT sensitivity and gain. In order to normalize the image data and extract the desired range, an "electronic" EDR process is applied to the resultant data in a manner analogous to the pre-scan method [2]. Final image output is described by 10-bits (1024 gray levels). Values identified by the EDR process include the maximum and minimum log photostimulated luminescence (PSL) signals, S_1 and S_2 respectively, in the image histogram as shown in Figure A2-4. Examination specific algorithms evaluate the shape of the histogram to determine the "useful" signal range. Within this range, the median input digital value, S_k , is "mapped" to the digital output value 511 in the 10 bit digital range[2]. The *Sensitivity number, S,* is calculated as: $S = \mathbf{4 \times 10^{(4-S_k)}}$, and is an index indicating the reading sensitivity and is inversely proportional to the incident exposure on the plate. The approximate relationship to the mean incident exposure is given as: exposure $\mathbf{(mR) \cong 200 / \mathit{S}}$ for standard x-ray beam conditions (80 kVp, ~3.0 mm Al HVL). The latitude number, ***L***, is an index representing the logarithmic range of digitization of the stimulated luminescence signals about the median value, S_k. ***L*** is calculated from the maximum and minimum luminescence values within the defined image area and the corresponding digital output values of the reading unit as:

$$L = 1023 \times (S_1-S_2) / (Q_1-Q_2),$$

where Q_1 and Q_2 are the digital values corresponding to the log PSL output signals S_1 and S_2 of the reading unit, respectively. An example image histogram with the above-mentioned parameters is illustrated in Figure A2-4. A S_k value of 2.30 corresponds to an incident exposure of 1.0 mR. The latitude of the image reader and ST image plate usually ranges from a logarithmic PSL intensity of 0.3 (0.01 mR) to 4.3 (100 mR).

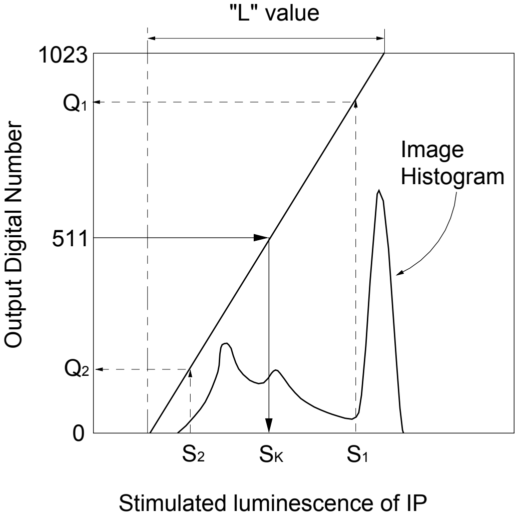


Figure A2-4. Sensitivity and Latitude numbers defined for the Fuji PSP system output parameters as related to the image histogram [adapted from ref A2]

The ***Semi-automatic*** mode reading conditions are applied using the histogram extracted from a pre-determined sub-region region of the imaging plate. A variety of user selectable regions are possible. A centered area on the IP of 10cm×10cm, 7cm×7cm, or 5cm×5cm, known as Types I, II, and III, respectively can be selected. A single 5cm×5cm area centered in one of 8 rectangular areas distributed about the image is defined as Type III (xy). An alphabetic code is contained within the parentheses, where x refers to the horizontal position of the region corresponding to L (left), C (center), R (right), and y refers to the vertical position T (top), M (middle), B (bottom). A Type IV region, unique for thorax imaging, uses the highest mean value from 4 areas of 6×6 cm size positioned in each of 4 quadrants, and an overlapping 5th area of 10cm×10cm size. Analysis of the histogram determines the mean stimulated luminescence value S_k, for determining the overall reading sensitivity. In this mode, the fixed latitude (*L* number) associated with a specific image acquisition menu maps the range of PSL intensity into digital output values. Use of area sensing in PSP radiography is somewhat analogous to the use of a phototimer with a screen film system. Image quality is dependent on the technologist's ability to properly position the patient with respect to the sensing area and to use the appropriate kVp to match the pre-selected latitude. Adjustments of the area location and size can be accomplished with selection of alternate semi-automatic mode choices. For physicist acceptance testing, the semi-automatic mode is typically used in lieu of the automatic mode for calibration of *S* numbers and other tests.

Fixed sensitivity mode is the most basic method of reading out the signal on the PSP receptor. In fixed sensitivity mode the user defines the system speed and the latitude to be used for processing the exposed imaging plate. Thus the response in this mode is similar to a screen-film cassette. The technologist must select the proper kVp and mAs in order to produce a quality image.

The ***system sensitivity number*** as explained earlier, provides an estimate of the incident exposure on the plate, as determined by the Exposure Data Recognizer (EDR) subsystem for the automatic and semi-automatic modes. Under normal processing conditions for the standard resolution (ST) plates, the system sensitivity number is given as:

$$S \cong \frac{200}{\text{exposure (mR)}}$$

A large sensitivity number indicates a relatively low incident exposure. When the system sensitivity number is 200 with the semi-automatic or automatic mode, an average photostimulated luminescence within the area sensed by the PSP reader can be *estimated* as 1 mR (80 kVp, no object, no added filtration other than inherent). This corresponds to a digital value 511 (a central value of the 10 bit grayscale range). Therefore, the sensitivity number is not directly correlated to the surface dose of objects but to the median x-ray exposure that has passed through the anatomy and absorbed on the imaging plate. Even though the exposure on the surface of objects is the same, the sensitivity number could be different because of positioning and thickness/anatomical variations. Beam hardness (effective energy of the transmitted x-ray beam), kVp, and the time delay between exposure and imaging plate readout will also cause variations in the sensitivity estimate. For the fixed mode, the sensitivity number is independent of the incident exposure on the plate, and does not change with exposure (although the resultant film density does change).

Specific measurements

Laser printer calibration/Sensitometry

For the integrated Fuji AC-1 system, a three-point and sixteen-point optical density range is created on the output film. Each OD step should be measured with a calibrated densitometer and compared to the allowed range of values indicated in the user manual. For the recent laser printer, FL-IMD, a 17-point optical density range is created. This capability allows a check of the film processor as well as the internal power level settings and adjustments of the laser imager. Huda discusses an independent review of this capability. [ref on calibration method of the laser printer/processor~~.~~

Imaging Plate Dark Noise

For this test, process previously erased plates using a fixed mode (i.e. system sensitivity =2000, latitude =2.0). For hard-copy output, a 2:1 image format is recommended in order to visualize normal and frequency enhanced images (e.g., the default setting for the *Contrast* test mode algorithm). Optical density, measured randomly over the image area, should be within 0.05 OD of base + fog values determined from the film sensitometry strip. The junction between the main unit and the film processor could cause excess optical density and fogging. For soft-copy image display, use the image display software to enhance the image contrast and brightness settings to verify the lack of patterned noise or shading in the displayed image. If problems are detected, erase another imaging plate and repeat the process. If still detected, the PSP reading system should be suspected as causing the problems, otherwise the imaging plate is the likely cause.

Imaging Plate Response: Uniformity and Density Output

Several imaging plates should be *uniformly* exposed with an 80 kVp beam at 180 cm SID. A processing selection that provides enhanced sensitivity (e.g., the sensitivity selection program under the *test* menu) is desirable. Type I semi-automatic mode with linear LUT (curve A), an average output film optical density output of 1.2, a normal (unprocessed) right image, and a frequency processed left image (2 on 1 format) are the normal default parameters for this menu selection. Optical density of the center position and 4 locations centered in each quadrant should be within ± 0.2 OD over the total area of the image on an unprocessed image. Variations across the images due to the heel effect can be compensated by a double –exposure. When the variation is noticeable and causes the OD to exceed the recommended variation limits, repeat the exposure with a fresh imaging plate to ½ the mAs, turn the cassette 180°, and re-expose with the same technique. This will reduce variations caused by the x-ray distribution so that other causes of non-uniformity can be elucidated. Variations across the field of view due to the PSP equipment can be ameliorated with shading correction algorithms built into the PSP reader. Seek the assistance of approved service engineers to perform this function.

System Linearity, Auto-ranging and Sensitivity Response

The purpose of this test is to verify the correct histogram normalization function and calibration of the sensitivity number. Use the *sensitivity* selection under the *test* menu for IP processing. The system sensitivity indicator should be inversely related to the mAs (incident exposure) with values of 2000 ± 10%, 200 ± 10% and 20

± 10% for the suggested incident exposures of 0.1, 1.0, and 10.0 mR, respectively (80 kVp, 180 cm SID, no added filtration). The gradient of system linearity (G) defined in the equation below should be 1.0 +/- 0.1 under these processing conditions.

$$G = \left| \frac{\log S2 - \log S1}{\log E2 - \log E1} \right|$$

In the above equation, E is incident exposure (E1 ~ 0.1 mR; E2 ~ 10 mR), and S1, S2 are the system sensitivity numbers corresponding to E1 and E2.

Film optical density is acceptable if the range for each film falls within 1.20 +/- 0.10 (or to the programmed density) for all normal images.

Laser Beam Function

A high contrast straight edge object (e.g., steel ruler) is positioned on a 14 × 17 cassette over the center area, slightly angled with respect to the long axis of the cassette. X-ray techniques at 80 kVp, 180 cm SID and mAs to deliver approximately 5 mR to the IP, and the *sensitivity* selection under the *test* menu with a 1 on 1 image format are recommended for acquisition and readout, respectively. Since the sensitivity adjustment area (semi-automatic Type I) window is positioned under the shadow of the ruler, film density in the open areas of the image will be increased for easier determination of scan line performance. Look for the edge to be smooth and straight on the film image with a 10X loupe, or use a magnification view of the image on the soft-copy display terminal. Scan line artifacts or point dropouts/inclusions in the open area of the image indicate a potential problem, which should be brought to the attention of vendor maintenance personnel.

Spatial Resolution

The cassette/IP is exposed to a technique to reduce image noise and enhance subject contrast, (e.g., 80 kVp, 5 mR incident exposure, 180 cm SID) and processed using the *sharpness* selection under the *test* mode (semi-automatic speed and fixed latitude, *L*=1.0). Spatial resolution tests include measurement of the central *and* peripheral resolution in the scan and sub-scan of each IP size for 1-on-1 and 2-on-1 film hardcopy image output formats, as well as the soft copy monitors in full-field-of-view display and image magnification modes.

In the case of video display monitors, image magnification and contrast enhancement should be performed to estimate the limiting resolution. Little or no difference in the scan and sub-scan resolution measures should be evident, and the limiting resolution should be within 10% of the resolution specified.

Low Contrast Resolution (Contrast Sensitivity)

The contrast resolution phantom (e.g., Leeds TO.16 and Leeds TO CR (DR) [3] or the UAB phantom [4]) radiograph should be acquired with the phantom manufacturer recommended techniques. This includes kVp (e.g., 75 kVp) and mAs to achieve an incident exposure to the IP of approximately 10 mR, 1 mR and 0.1 mR on separate plates. Process the exposed plates with the *contrast* selection under the *test* menu with a 1-on-1 film format and no frequency processing. Discern the minimum detectable contrast object according to the phantom instructions. Verify that the perceptible percent contrast decreases with decreased incident exposure. For image workstations, quantitative methods can be employed using region-of-interest data analysis to determine contrast and signal-to-noise ratio values, in addition to the subjective qualitative tests.

Distance Measurement; Geometrical Uniformity and Aspect Ratio Accuracy

Using several images previously acquired for the resolution test pattern measurement and the known dimensions of the test object, distance measurements in the horizontal and vertical directions can be made directly on the film images and corrected for the image reduction factor. Corrected distance measurements should be within ±5% of the actual values. For an image workstation, verify the calibration of pixel size and measure the object with distance measurement tools. The same evaluation criteria for hard copy images should be used (within ±5%).

Geometrical uniformity and aspect ratio accuracy should be assessed in the central and peripheral areas of the image using a circular or square attenuator (e.g., aluminum disks) placed on the cassette. Using the distance measurement tools available, verify the circularity or squareness of the object across the image, particularly in the scan and sub-scan directions. The aspect ratio should be 1.0 ± 3%.

Other Tests

1. Automatic, semi-automatic and fix modes (the readout algorithms) should be tested for proper function. Note that each manufacturer selling Fuji products often have their own algorithms, names and functions. The effect of collimation, exposure, and (mis) positioning should be verified using anthropomorphic phantoms and standard clinical image menus.
2. Characteristic curve look-up-tables for the different image menus can be determined with the use of a calibrated x-ray step wedge and fixed speed processing. The characteristic curve(s) should approximate the description(s) found in the applicable operations manual.
3. Frequency processing parameters should be tested and verified for proper function as described in the operations manual, including the parameters for frequency rank, frequency boost, and frequency type
4. Imaging plate throughput
5. Anthropomorphic images

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15. 3 Appendix 3. Eastman Kodak Company

Kodak Appendix to AAPM CR Task Group Document
1/15/98

Introduction

The first KODAK EKTASCAN IMAGELINK☺ Critical Care System was installed in 1992. The KODAK DIGITAL SCIENCE☺ Computed Radiography System 400 was commercialized in 1995. Both systems are thoroughly described elsewhere (1). Below is a brief description of how the systems work, but the main purpose of this appendix is to outline the steps for acceptance testing the equipment as defined by the AAPM computed radiography task group. Unless specified, this appendix covers both KODAK CR Systems. While this appendix includes most of the steps and menus needed to conduct the tests, user's manuals for the computed radiography system and the Quality Control Workstation (QCW) should be referred to for specific system operation (2,3). Acceptance testing is also described in a Kodak Technical and Scientific Bulletin (Acceptance Testing and Quality Control of Computed Radiography Systems) (4).

System Functional Overview

The KODAK EKTASCAN IMAGELINK Critical Care System and the KODAK DIGITAL SCIENCE Computed Radiography System 400 acquire and process the computed radiograph in the same way. The exposed phosphor screens are placed in the storage phosphor reader or autoloader (which holds 10 cassettes at once). The storage phosphor screen, mounted on an aluminum panel, is extracted from the CR cassette and scanned with a helium-neon laser. The light emitted from the phosphors is directed to a photomultiplier tube by an optical cavity. An analog-to-digital converter digitizes the signal from the photomultiplier tube(s) and the digital image is formed.

Kodak sells two types of CR screens, the general purpose KODAK EKTASCAN GP-25 and the high resolution HR Storage Phosphor Screens. Both screens are made from identical europium-doped barium fluoro-halide (where the halide is bromide or iodide) photostimulable storage phosphors. The difference between the GP-25 and HR screens is the thickness of the phosphor layer. GP-25 screens are available in 18 by 24 cm, 24 by 30 cm and 35 by 43 cm sizes, while the HR screens are available only in the two smaller sizes. In the reader, the 18 by 24 cm and 35 by 43 cm screens are scanned by the laser (in the fast scan direction) along their short axis. The screens are moved under the laser scan lines in the slow scan direction. The laser scans 24 by 30 cm screens along their long axis.

The light from the phosphor screens is detected using the same photomultiplier tube and analog-to-digital converter settings for every image. Four decades of exposure from 0.01 mR to 100 mR are digitized for each image. In the storage phosphor reader, this 16-bit linear data is then mapped to 12-bit (4096 grey level) log data. The image is transferred to the Quality Control Workstation (QCW).
In the QCW, tone scale algorithms calculate the look-up table needed to optimally display each radiograph. This is a contrast curve based on an analysis of the histogram and cumulative distribution function of the image data. There are no fixed look-up tables for the images. The body part specified for each exam and the image processing parameters will determine the image display.

Unsharp masking frequency enhances the computed radiography images. It is a mathematical equation applied to the image, which changes the image pixel code values. The matrix (kernel) size and the boost factors control edge enhancement. Larger matrix sizes result in enhancement of lower resolution objects. After processing, the image appears on the QCW for review and further manipulation.

The QCW displays an 8-bit image, one-third its actual size. It can be used to modify the tone scale (look-up table), edge enhancement, and window and level of the image. An individual image can be reprocessed at the QCW and printed, saved to tape, or sent to a workstation from the "Send Exam" menu. Also using the QCW "Patient Information" and "Exam Information" menus, the patient information (name, identification, physician, bed number, etc.) and exam information (technologist identification, projection, body part, position, exposure condition, etc.) can be reviewed and changed. For example, the image can be reprocessed as a different body part.

The raw (unprocessed) image data is always accessible as long as the image is on the QCW. Some of the tools in the QCW can be applied to the acceptance and quality control testing of the storage phosphor reader. For instance, using a QCW window width of one and leveling through the image can approximate the pixel code values in a radiograph. This type of analysis facilitates isolating problems with the storage phosphor reader separate from the laser printer and processor. The methods described below for acceptance and quality control testing of the storage phosphor reader rely both on laser-printed film and the QCW.

Readout Parameters

This section briefly describes the image processing readout parameters printed on CR films. The patient, exam and processing information is printed on the bottom of every film.
To correctly display the contrast in an image, the relevant portion of the image, corresponding to the patient anatomy, must be identified. In the QCW, edge detection algorithms find the collimation edges (if any) and the outline of the anatomic region. The anatomic area is then used to calculate the tone scale (or look-up table) for that image. There are four contrast curves available on the QCW. These are "raw data," "default," "high contrast" and "blackbone". The look-up tables should be selected from the "Image Processing" menu when the image is displayed on the QCW.

Information about the unsharp masking is also printed on the film. The matrix size (between 7 and 151) sets the kernel used for convolving the image. It is printed after ✌Matrix✍ on the film. The low and high boost factors control the amount of image enhancement in the low and high optical density regions of the image. They are printed as ✌HighDen✍ and ✌LowDen✍ on the film and can range from zero to 9.99. Edge enhancement options available and printed after ✌Boost factor✍ on the film are "none," "default," "smoother," "sharper" and "custom." These also can be selected from the "Image Processing" menu on the QCW. Using the "custom" setting, any matrix size and boost factors can be selected.

The window and level settings appear on the film as W/L. Normally for clinical exams, these will be set to a window of 4095 and a level of 2048 (e.g., 4096/2048 on the film).

The identified anatomic region is used to calculate the exposure index. The exposure index is the value that indicates the exposure to the phosphor screen. Because storage phosphors have a linear response to radiation exposure, digital image manipulation can optimally display the contrast in the image regardless of the exposure used. The exposure index serves as an indication that an appropriate exposure was used to form the image. It can be found under the QCW "Exam Information" menu. If an image is noisy, the exposure index should be checked to see if it is low. The exposure index is related to the phosphor screen exposure according to the equation:

$$\textbf{Exposure Index} = 1000 \times \log(\text{exposure in mR}) + 2000$$

This relationship is based on a 15 minute delay after an 80 kVp exposure with 1 mm of aluminum and 0.5 mm of copper filtration. This equation holds for both GP-25 and HR screens and so is useful for calculating any exposure to a screen based on the exposure index. The exposure index calculation compensates for the thinner, less energy absorbing HR screens.

The exposure index will increase with the screen exposure. Factors that influence the exposure index calculation are: the image processing, the x-ray beam energy, beam filtration, grids, the delay between the screen exposure and readout, and variations in the brightness of different phosphor coatings. These factors have been taken into consideration in the acceptance testing protocols.

Acceptance and Quality Control Testing

The goal of CR acceptance testing is to ensure the system is functioning correctly to produce the best possible image quality. Quality control then ensures that the system performance and image quality are not changing. While limits are given below for system acceptance, tracking the system performance over time is essential to make sure the test results do not vary significantly.

Depending on the number of phosphor screens tested, these tests can take up to 8 hours. However, because the system does not have to be shut down, it is not necessary to interrupt clinical use of the system. Also, with careful planning, some of the tests such as test 8, 9, 11, and 13 can be combined into a single exposure.

Before beginning the tests, make sure the x-ray tube being used is calibrated and has a reproducible output.

Some Test Guidelines

The body part PATTERN is used for all but the last quality control test because it bypasses the anatomic look-up table generation. Normally, a unique tone scale curve is calculated for the established anatomic region in the image but, for a non-anatomic quality control test, it will be meaningless. In addition, when using the PATTERN option, the exposure index is calculated as an average pixel value over the entire phosphor screen.

The QCW is used during acceptance and quality control testing for image analysis as well as to ensure correct processing of the images. However, because the images displayed on the QCW are one-third their actual size and displayed at 8-bit quantization, the QCW images alone should not be used for evaluating the storage phosphor reader performance.

It will be necessary to use the QCW and the bar code printer to generate an ✌Acceptance Test✍ patient bar code label for these tests. This ✌patient✍ should have a unique identification number, unlike any hospital patient numbers. When setting up this patient, the destination of the images must be selected. For acceptance and quality control testing, it is best to have the images simply go to the QCW, where they can be modified before being printed. These images should not be sent automatically to any soft copy displays.

1. Inventory

KODAK DIGITAL SCIENCE Storage Phosphor Reader (including touch screen/monitor)
KODAK DIGITAL SCIENCE Computed Radiography Cassette Autoloader

KODAK DIGITAL SCIENCE Computed Radiography Cassette
with GP-25 Screen
with High Resolution Screen
KODAK DIGITAL SCIENCE Computed Radiography Cassette Storage Unit
KODAK DIGITAL SCIENCE Computed Radiography Cassette Adapters

Quality Control Workstation
SUN SPARCstation
Monitor
150 MB tape drive (optional)
Service modem
Expansion disk drive (optional)
Bar Code Printer
Bar code printer labels
Portable Bar Code Scanner
Communications cable
Wall mount charger

Battery pack

Uninterruptible Power Supply
Remote Patient Data Entry Terminal
KODAK DIGITAL SCIENCE Remote Cassette Identification Station (optional)
User's Manuals

2. Monitor Calibration

Before beginning any tests, make sure the QCW monitor display is correctly calibrated. This should be done using a Society of Motion Picture and Television Engineers (SMPTE) pattern RP-133. Instructions for displaying the SMPTE pattern on the QCW are available from a Kodak field engineer and may have been invoked during system installation. KODAK Publication No. MB3437-17 (Modification Instructions for the Quality Control Workstation for KODAK DIGITAL SCIENCE Computed Radiography System 400) reviews these procedures. At the minimum, verification that the 0% - 5% and 95% - 100% patches of the SMPTE pattern are simultaneously visible with the widest window width and middle window level setting of the display contrast. Adjustment of the analog contrast and brightness settings is performed if these patches are not visualized at the same time. The line-pair resolution charts throughout the image and intensity range of the grayscale patterns are evaluated for proper function.

3. Laser Printer Calibration

Refer to your laser printer user's manual to determine how to generate the test patterns recommended below.

The laser printer(s) connected to the CR system must also be calibrated before beginning the acceptance or quality control tests. Daily quality control using laser-generated sensitometric strips tracks the performance of the laser printer and laser film processor. Based on the results of the daily quality control tests, the laser printer calibration compensates for changes in the processor chemistry or film emulsion.

A flat field should be printed before testing the computed radiography system. The flat field test pattern is printed with a fixed code value across the entire film. Examine this film for banding.

The SMPTE test pattern RP-133 is also stored in many printers. This pattern should be printed to further ensure correct printer operability, including line integrity and low and high contrast resolution.

4. Storage Phosphor Screens

Acceptance testing of the computed radiography system should include a complete inventory and inspection of all the cassettes and screens. Record all the cassette numbers and the phosphor screen coating numbers. The coating number is the first four digits of the number printed along the side of the phosphor screen. The cassette must be opened and the screen extracted for this number to be visible. Inspect each screen for dust or scratches. Look along the edges to verify that the screens are well sealed. Make sure all screens are firmly attached to the panels. Screens should be cleaned using alcohol, KODAK Intensifying Screen Cleaner and Antistatic Solution, or particle transfer rollers.

5. Cassette Throughput

The cassette readout should be tested to see if it meets the system specifications. Because the CR system is available with and without the autoloader, it can be tested in several ways. With manual feed-through, cassettes should be inserted for readout and replaced as quickly as possible. If there is an autoloader, the bar at the front of the autoloader can be disconnected and the CR system operated in manual feed-through mode. Otherwise, with the autoloader, ten cassettes should be loaded into the autoloader and read out. As the cassettes are read out, additional cassettes can be placed in the autoloader. This can be repeated for an hour. Another option is to see how long it takes to read out ten cassettes and then extrapolate to a screen throughput per hour.

The autoloader specification that follows was extrapolated from the readout of 10 cassettes. It is the time from when the "start" button was pushed until the last image appeared on the QCW.

Cassette Size	Autoloader Plate Throughput/Hour*	Manual Feed Plate Throughput/Hour*
18 by 24 cm	46	53
24 by 30 cm	44	51
35 by 43 cm	42	50

*Storage Phosphor Reader for KODAK DIGITAL SCIENCE Computed Radiography System 400 specification. The throughput is dependent on both the screen size and the magnitude of the screen signal. Because the screen erase time is determined by the highest exposure on the screen, the throughput will vary with the exposure level. These numbers are based on 26 mR exposures. The throughput of the images to the QCW is also dependent on the number of images stored on the QCW. If files must be deleted before new images can be stored, the system will slow down, decreasing the throughput.

6. Phosphor Screen Dark Noise

Erase each screen, and read out the image using the PATTERN body part option. Erasing the phosphor screen with visible light removes any residual signals built up on the screen since the previous exposure. Using the QCW "Image Processing" menu, select "raw data" tone scale and "none" under edge enhancement. Set the QCW level to 512 and the QCW window width to 1024 and send the image to the printer.

Look for specks or streaks on the film, but some bands may be visible. Bands are present in the dark noise image because a ✌collector profile✍ is applied to compensate for variations in the light collection efficiency across the phosphor screen. The collector profile is simply added to the image data. Consequently, the resulting film will not be completely clear and uniform. Some vertical bands in the image (horizontal bands in the 24 by 30 cm screens) are expected and should be identical from screen to screen. These bands should not prevent the acceptance or quality control tests from continuing. Window (set to 1) and leveling the image on the QCW can establish the code values of the bands. Any artifacts other than the bands should be further evaluated.

The exposure index for an erased screen should be found under the "Exam Information" listing. The collector profile compensation (and thus the bands) ensures that the exposure index will not be zero in the dark noise tests. Phosphor screens of the same size should have the same exposure index values in these tests.

The exposure index (as defined in the equation above) compensates for the reduced light output of the thinner HR screens by adding extra 300 values to the calculated exposure index. This is necessary so that the exposure index will be consistent regardless of the screen for a given exposure. When there is no signal on the HR screens they should have exposure indices about 300 values greater than the GP-25 screens.

Typical exposure index values for erased GP-25 screens are less than 100 while for HR screens the exposure index should be less than 400.

7. Phosphor Screen Response: Uniformity and Density Output

These exposures require 0.5 mm copper and 1.0 mm aluminum filtration with the x-ray beam centered on the cassette. A uniform x-ray exposure (without a grid) is essential for this test. The x-ray generator exposure flatness should be independently verified using a conventional screen-film combination. To test the storage phosphor reader performance, use a 10 mR exposure (measured at the cassette plane), 80 kVp and a long (~180 cm) source-to-image distance (SID) collimated outside of the cassette. For each test make sure the time delay between exposure and screen readout is consistent.

Read out each screen using the PATTERN body part. At the QCW "Image Processing" menu, select "raw data" tone scale and "none" under edge enhancement. The resulting images should be sent to the printer with the QCW level set at the exposure index value (found under "Exam Information") and the QCW window width set at 1024. Note: For HR screens, set the level to 300 values less than the exposure index.

With this 0.5 mm copper and 1 mm aluminum filtration, a 10 mR exposure to the screen should result in an exposure index of 3000. It is important to verify that all the three phosphor screen sizes, as well as the HR screens, accurately reflect the screen exposure. When calculating the screen exposure from the exposure index there should be less than 10% variation of the calculated exposure from the measured exposure. Exposure indices outside this range may reflect variation in the x-ray tube output or, because the signal on the screen decays exponentially with time, differences in the time delay between screen exposure and readout. Large differences in exposure index between different-sized phosphor screens may mean that equipment service is required.

Check each film for horizontal or vertical banding artifacts. Because 18 by 24 cm and 35 by 43 cm cassettes are scanned by the laser along their short axis, vertical bands can indicate a fast scan problem and horizontal bands a plate transport anomaly. The 24 by 30 cm cassettes are read out in the opposite orientation so vertical bands can reflect a plate transport problem.

Look for black or white spots or streaks in the image (this can be dust on the phosphor screen, dust on the collector, laser dropout or laser printer artifacts). A flat field result verifies that the collector profile has been correctly applied to the image. Measure the film optical density in four quadrants of the image. The film optical density should be +/- 0.10 over different areas in the image. If there are still bands in the image perpendicular to the laser scan direction (and similar to those seen in the dark noise tests), the collector profile may have to be recalculated by a Kodak field engineer. Re-verify the x-ray beam flatness and the laser printer flat field pattern before contacting the field engineer for equipment service.

Each film should have a similar optical density and exposure index. Differences in exposure index from screen to screen can be compared to the screen coating numbers recorded in the inventory.

Large light lines along the edge of the film border mean that the entire screen is not being read out. The screen may be incorrectly mounted on the aluminum panel or the collection system may not be correctly aligned. The writing along the edge of the phosphor screen (indicating the phosphor screen type and coating number) may be visible.

8. System Linearity and Sensitivity Response

This test checks the linearity of the storage phosphor reader response and ensures proper calibration of the photomultiplier tube gain.

Filtering the x-ray beam with 0.5 mm copper and 1 mm aluminum, expose the screen at 80 kVp and 180 cm source-to-image distance. Collimate the x-ray beam outside of the cassette for 0.1, 1.0, and 10 mR exposures (measured at the cassette plane). Ideally, the same screen will be used for each exposure and with the same time delay between exposure and screen readout. All exposures should be processed using the PATTERN body part.

Verify the exposure index for each exposure on the QCW using the "Exam Information" menu. The results for either GP-25 or HR screens should be:

Exposure (mR)	**Exposure Index**
0.1	1000

1	2000
10	3000

The exposure index should correlate to within 10% of the measured exposure. These exposure index values can vary based on the x-ray beam quality, beam filtration, the delay between screen exposure and readout, backscatter, and the phosphor screen coating (as checked in test 4). Plotting the exposure index versus the log-measured exposure should be roughly linear.

If these images are to be printed, "raw data" tone scale, and "none" under edge enhancement should be selected. At the QCW, the level should be set at the exposure index and the window at 1024. The films can then be examined to ensure they are flat fields with no banding, streaks, spots or artifacts in them. The optical density on the films should not change with the exposure (if the level is set to the exposure index) and for a flat field exposure should be +/- 0.10 across the film.

The images can also be reprinted with edge enhancement to better visualize the noise. For this, under the "custom" edge enhancement option, set the matrix size to 19, with high and low boost factors at 0.8. Noise should decrease with increasing exposure index.

9. Laser Beam Function

This test checks the laser scan line integrity by looking for laser beam jitter or line dropout in the fast and slow scan directions.

Use 60 kVp and an 180 cm SID to make a 5 mR or 10 mR exposure to a 35 by 43 cm cassette. A steel ruler (or high attenuation straight-edged object) should be placed along the long axis of the cassette.

Process the exposure using the PATTERN body part. At the QCW "Image Processing" menu, select "raw data" tone scale and "none" under edge enhancement. In the "Exam Information" menu find the exposure index. Set the QCW level to the exposure index and the window width to 800. Print the image and look along the edge of the ruler for under- or over-shoot scan lines. Both ruler edges should be straight and continuous over the full length of the film. Image scan lines are viewed with a 10X loupe in various areas across the film to check for uniform spacing. Scan line dropout is detectable as lucent straight lines in the open field and can represent dust particles on the optical cavity or photomultiplier tube.

10. Spatial Resolution

CR resolution is affected by many factors including the phosphor screen thickness, the pixel size, and the laser spot size. The resolution should be measured using GP-25 and HR screens and different-sized screens, because the pixel size varies with screen size. These tests should be done without edge enhancement.

Spatial resolution tests include measurement in the central and lower left of the screen. The line pair phantoms are placed on the cassette to measure resolution in both the fast scan (laser scanning) and slow scan (plate transport) directions. The resolution should not be tested with the bar pattern at a 45-degree angle to the scanning direction. This causes the effective pixel sample size to be less than the actual so the measured limiting resolution will be higher than the theoretical calculation. Alignment of these bar patterns is critical. The cassette/screen is exposed to 60 kVp to maximize subject contrast, and 180 cm SID, to deliver about a 10 mR exposure. The lowest (a 35 by 43 cm cassette with a GP-25 screen) and highest (a 18 by 24 cm cassette with an HR screen) resolution capabilities of the system should be tested.

Process the exposed bar pattern image using the PATTERN body part. Select "raw data" tone scale, and "none" under edge enhancement. Set the QCW level to the exposure index value (found in the "Exam Information" menu) and the window width to 800. For HR screens the level should be set to 300 values less than the exposure index.

The bar pattern must be examined on a film, because the QCW image is sub-sampled and is not displayed at full resolution.

The theoretical limiting resolutions and test limits are as follows:

Screen Size	**Digital Matrix**	**Spatial Resolution**	**Limiting Resolution***	**Acceptable Performance**
18 by 24 cm	1792 x 2392	10 pixels/mm	5.0 lp/mm	HR 4.8 lp/mm
24 by 30 cm	2048 x 2500	8.3 pixels/mm	4.2 lp/mm	
35 by 43 cm	2048 x 2500	5.8 pixels/mm	2.9 lp/mm	GP-25 2.8 lp/mm

*Limiting resolution is estimated by the specified readout sampling rate in pixels per millimeter divided by 2 (the Nyquist criterion).

Measured resolution is determined by the average resolution in both the horizontal and vertical directions. Little or no difference in horizontal and vertical resolution measures is expected.

If the results are more than 10% below the above values, the film should be reprinted using a different level setting closer to the code values in the bar pattern. Other low results can occur when the bars in the pattern are not perpendicular to the laser scan. Reposition the line pair phantom and repeat the test. Corrective action is required if the results differ by more than 10% of the above acceptable values.

There is no theoretical difference in limiting resolution between the general purpose and high-resolution screens. However, because the HR screens have a thinner phosphor layer than the GP-25 screens, the effective laser spot size (the excitation area) is smaller, the modulation transfer function is higher and the images will be sharper.

11. Wire Mesh Test

A screen-contact tool can be used to show areas where there areas of image distortion due to movement of the laser or screen. Place a wire mesh tool on the cassette and expose to 5 mR with a 60 kVp exposure and a 180 cm SID.

Process the phosphor screen using the PATTERN body part. At the QCW "Image Processing" menu, select "raw data" tone scale, and "none" under edge enhancement. Set the level to the exposure index and window to 1024. Print the image and look for distortions in the mesh pattern.

This test should be repeated with all screen sizes, setting the level to 300 less than the exposure index for the high-resolution screens.

12. Low Contrast Resolution

Expose a phantom according to the manufacturer's recommendations. Process the phosphor screen using the PATTERN body part. At the QCW "Image Processing" menu, select "raw data" tone scale, and "none" under edge enhancement. Set the level and window to bring out the most features in the phantom. Check the visibility of the phantom features on a printed film.

13. Accuracy of Distance Measurements and Aspect Ratio

Use a high contrast, known-sized test object placed on the left and right sides of a 35 by 43 cm CR cassette, and expose the screen to 10 mR using a relatively low kVp (60 kVp) and long source-to-image distance (180 cm). Process the phosphor screen using the PATTERN body part. At the QCW "Image Processing" menu, select "raw data" tone scale, and "none" under edge enhancement. Set the level to the exposure index and window to 800, or narrower. Print the image and measure the object size on the film. This test should be repeated for all three cassette sizes.

On the film, measure the dimensions of the test objects on both sides of the image. The "squareness" of the object (the percentage difference between measurements in the x and y directions) in the film should be verified as less than 3%.

The printed object size will be affected by the number of images on the film, the border around the film, the printer interpolation, and the difference between the laser printer pixel size and the computed radiography pixel size. Image sizes are included below for single images printed directly from the QCW. The changes will be the same in the fast (laser) scan and slow (plate transport) scan directions.

	KODAK EKTASCAN 2180 Laser Printer		**KODAK EKTASCAN Laser Printer, Model 100 XLP**
Cassette Size	**35 by 43 cm Film**	**28 by 35 cm Film**	**35 by 43 cm Film**
18 cm by 24 cm	99%	98%	101%
24 cm by 30 cm	94%	98%	101%
35 cm by 43 cm	94%	75%	98%

14. Accuracy of Erasure Cycle

Expose a screen to 100 mR (filtration is optional) with a high contrast object in the center of the cassette. Erase the screen. Re-expose the screen to 1 mR (using 80 kVp, 0.5 mm copper and 1 mm aluminum filtration, and a 180 cm SID). Read out the screen using the PATTERN body part. Check the exposure index and make sure it is similar to what was found in the linearity tests above (close to 2000). Window and level through the image to try to see any residual signal from the high contrast object.

15. Processed Image and Unsharp Masking Frequency Parameters

This test should be done with a phantom or a patient image. Process the exposure by selecting the appropriate anatomic region. Select different boost factors and matrix sizes using the "custom" edge enhancement on the QCW. The matrix size can be varied from 7 to 151 while boost factors can vary from zero to 9.99. Combinations of boost factors and matrix sizes will have been varied by the applications consultant during CR system set up when selecting the appropriate image processing parameters at your hospital.

References

1. Bogucki TM, Trauernicht DP, Kocher TE. *Characteristics of a Storage Phosphor System for Medical Imaging.* KODAK Publication N-331, 1995.
2. *User's Guide for Model 3110 and Cassette Autoloader.* KODAK Publication 2B6826.
3. *User's Guide for Quality Control Workstation.* KODAK Publication 968156.
4. Bogucki TM. *Acceptance Testing and Quality Control of Computed Radiography Systems.* Kodak Publication N-333, catalog number 8792038, 1997.Kodak Appendix to AAPM Task Group Document "Acceptance Testing and Quality Control of Computed Radiography Imaging Systems"

15.4 Appendix 4. Agfa

Introduction:

AGFA has distributed its Computed Radiography system, the AGFA Diagnostic Center (ADC 70), in the United States since 1995. AGFA CR products are also distributed through OEM arrangements with Toshiba and SwissRay. The current AGFA CR product is the ADC Compact, which has a smaller footprint, identical performance characteristics, a similar operator workflow, but utilizes newer technologies and different network connectivity. Storage phosphor images are produced using a HeNe laser. PMT output, initially linear with x-ray exposure, undergoes square-root amplification and is then digitized by a 12 bit Analog-to-Digital Converter. *Because quantum noise also increases as the square root of the exposure, in theory, the uncertainty translated into terms of absolute digital grayscales is a constant value independent of exposure level.* The signal-to-noise ratio still improves as exposure increases. *For an individual image,* AGFA guarantees *log*-linear output over a dynamic range of 500:1 in exposure.

AGFA ADC systems can be configured for a variety of operational scenarios, from standalone automatic filming to distributed, networked environments that incorporate redundancy, RIS connectivity, quality control confirmation of each image, and filmless image distribution. To support the wide range of operational scenarios, AGFA has developed QC and Service software and hardware tools to assure consistent high quality performance by all components and the total system.

Functional Specifications:

ADC Compact
(ADC 70 only)

Image plate / cassette size	Active Area cm	Digital Matrix	Sampling Rate* pixels/mm	Throughput** plates/hr
18x24 cm	17.2 x 23.2	1518 x 2048	9	70
		(1536)		
8x10 in	19.5 x 24.4	1721 x 2172	9	70
		(1664 x 2080)	(8.5)	
24x30 cm	23.2 x 29.2	2048 x 2578	9	70
		(2560)		
10x12 in	24.6 x 29.7	2172 x 2621	9	70
		(2024 x 2458)	(8)	
21x43 cm (Compact only) (partial scan of 35x43 cm cassette)	20.2 x 42.4	1784 x 3743	9	70
(20x40 cm)		(1536 x 3072)	(8)	(70)
(18x43 cm)		(1408 x 3419)	(8)	(70)
35x35 cm	34.8 x 34.8	2048 x 2048	6	70
35x35 HR (Compact only)	34.8 x 34.8	3072 x 3072	9	nd
35x43 cm	34.8 x 42.4	2048 x 2537	6	70
		(2496)		

35x43 HR (Compact only)	34.8 x 42.4	3072 x 3743	9	nd
15x30 cm (Compact only)	14.2 x 29.2	1254 x 2578		n/a

Approximate values; ** Mechanical maximum including erasure cycle, without network bandwidth limitations; image availability also network dependent; nd = strongly network dependent, n/a = not available

Inventory:

The following basic hardware and software components comprise the ADC Compact CR system. Some components are options based on the specific configuration and operational scenario. Although functional similarities exist between components in the current product line and the ADC 70, there are significant differences that preclude interoperability between product lines.

ADC Compact Digitizer	Accepts cassette, reads imaging plate, outputs digital dataset to the Processing Server, erases imaging plate, reloads cassette. 10 cassette input/output buffer. Ethernet interface.
Preview/ID Station (PRID)	Accepts patient demographic information from operator or optional RIS interface, selects image processing options, selects routing options, reads and writes information onto cassettes via ID tablet. Displays images for QC confirmation before release to network. JAVA application running on PC with NT operating system.
ID Tablet	Provides RF interface between PRID and EEPROM/antenna embedded in imaging cassette. Can also be attached to Processing Server.
Processing Server (PS)	Accepts raw data from ADC Compact Digitizer, applies MUSICA® image processing according to exam menu, routes processed image via DICOM Print or optional DICOM Store.

Software and Accessories

ADC C ID Software	JAVA application that provides ID operator interface, and controls the ID tablet.
ADC C Rislink Software	DOS application that query's the network gateway, and retrieves patient demographic and exam information.
ADC C Preview Software	Receives processed image from Processing Server, displays image according to user-selected format, releases image to network, or holds image for repeat or re-processing.
ADC C Auto Processing Software	Applies MUSICA image processing to raw data on Processing Server according to exam menu.
ADC C Interactive Processing Software	Provides Processing Server with Graphical User Interface (GUI) that allows operator processing of image data.
ADC C Black Border	Applies cosmetic Optical Density mask based on locations of collimation boundaries on Processing Server automatically or

	manually.
ADC C Annotation	Allows operator of Processing Server to create text and measurement overlays and embed them into the processed image.
ADC C Uro/Tomo	Provides set of exam menus for Urology/Tomographic imaging.
ADC C Dental	Provides software for dental panorex imaging in conjunction with the 15x30 cm imaging plate.
ADC C Full Spine	Processing Server software to "stitch" images from multiple imaging plates in order to construct a composite scoliosis exam in conjunction with a special cassette insert.
ADC C DICOM	Makes Processing Server a DICOM Storage Class Provider (SCP).
ADC C Autorouting	Allows Processing Server to automatically distribute processed images to one or more hardcopy or softcopy output destinations, and/or archive. Allows routing of raw data to other Processing Servers.
ADC C Overview Printing	Allows Processing Server to print a collage of "thumbnail" images on a single laser camera film.
ADC C Slide Printing	Allows Processing Server to print 35mm-sized images to networked laser camera.
ADC C Dose Monitoring	Allows Process Server to keep track of radiation dose to imaging plates uniquely for 100 combinations of examination type, view, cassette size, speed class, and physician. Calculates a nominal value from the average dose of the first 50 exams of each combination or can be manually set. Compares the dose calculated for each exam to the nominal value for the matching combination and calculates a dose offset. Displays the dose offset with a thermometer graphic on the Processing Server and on laser camera prints.
ADC C Auto QA	Allows automatic analysis of the images of the QA phantoms.
ADC C QA Phantoms	Includes a Spatial Test Object and a Base Plate, a Contrast Test Object and a Copper Filter for producing test images under defined radiographic conditions.

System Functional Overview:

The AGFA ADC Compact computed radiography system produces customized images that are specifically processed for any combination of exam type, view, individual radiologist preference, and output destination. The AGFA ADC MD (second generation) storage phosphor plate is composed of barium strontium fluorobromoiodide activated with europium (BaSrFBrI:Eu). The cassette is placed into the ID Tablet, which can be a peripheral to either a Preview/ID Station or a Process Server. All relevant exam and demographic data is written to an EEPROM chip embedded in the ADC C Cassette via an RF transmitter. This data may include the following fields:

Patient Last Name	Patient First Name	Birth Date	Sex
Exam Type	Exam Sub-type	Exam Position	ID Date
RIS ID No.	Patient Code	Hospital Name	ID Time
Radiologist	Hardcopy Destination	Network Destination	Department

In addition to these fields, the operator can also choose to configure the system to include up to four DICOM fields, such as Patient Size, Patient Weight, kVp. Exposure mAs, Distance source-detector, Additional Patient History, or any of 16 other allowed DICOM elements. The information can be written to the cassette either before or after performing the exposure. The information can be entered manually by the operator, or with AGFA's RISlink software option, can be retrieved from the RIS via input of a key accession number field, either manually or by bar code or light pen input from a printed exam requisition. RISlink software in conjunction with AGFA's Worklist Gateway, can obtain demographic information via DICOM Worklist Management. The operator completes the cassette registration process by entering data that may not be available from the RIS, such as position and speed information, or comments.

Once registered, the cassette is placed in the input buffer of the ADC Compact Digitizer. Ten cassettes of any size and in any order can be placed in the buffer. No additional interaction with the digitizer is normally required. The ADC Compact Digitizer takes one cassette from the buffer, removes the phosphor plate and introduces it into the scanner mechanism. The scanner mechanism carries the plate past a 25mW HeNe laser. Stimulated light is transmitted via a fiberoptic array to a photomultiplier tube (PMT). The signal from the PMT undergoes square-root amplification before Analog-to-Digital conversion into a 12-bit dataset.

The EEPROM is read as the cassette enters the ADC Compact Digitizer. The digitizer for establishing dynamic range of digitization uses speed information. Destination information is extracted for routing of the image and all other information is composed into a DICOM header and appended to the raw image data. The imaging plate is erased by exposure to high intensity visible light and reinserted into its original cassette. The cassette is transferred to the output buffer, which can contain up to ten cassettes that are ready for reuse.

Image Processing:

The ADC Compact generates a single 12-bit raw image data set with a DICOM header that contains the demographic text data and image processing information. The raw image data file is transmitted to the Process Server where raw image data is converted into a 12-bit Laplacian Pyramid parent data set. The Process Server utilizes AGFA's proprietary MUSICA® software to generate exam and demographic specific images according to the data that was entered by the Preview/Identification Station (PRID) via the cassette EEPROM.

The original image is decomposed into twelve images, each representing about one octave of different spatial frequencies[Vuylsteke and Schoeters, "Multiscale Image Contrast Amplification (MUSICA)" Proceedings SPIE 1994 2167:551-560]. A variety of image processing techniques can be applied in differing amounts to some or all of these twelve component images. The effect of processing is apparent on reassembly of the component images.

MUSI-contrast:

MUSI-contrast normalizes the amplitude of features without regard to feature size. Prominent features are attenuated while subtle features are accentuated. The pyramid parent data set is modified according to a non-linear conversion function that augments low amplitude values and reduces large amplitude values. The degree of MUSI-contrast is user-selectable between 0.0 and 6.0 arbitrary units.

Edge Contrast:

Edge contrast affects the weight given to the three highest frequency component images. User-selectable settings for 0.0 to 6.0, increase the amplitude of small features, making edges more conspicuous. Edge contrast also amplifies noise, which presents in high frequencies.

Agfa ADC Auto QA Test tools and Software

Exposure Level Monitoring:

The ADC 70 system can be configured with this *optional* software tool. The tool automatically indicates the relative exposure a plate received for a particular examination / view. A graphical indicator is displayed in the text fields of each image. The graph indicates the statistical average mean exposure for the specific examination / view compared to the relative over or under exposure level of the current image.

If the exposure exceeds specific thresholds, a visual black warning bar is printed and warning messages are logged into a disk file.

The ADC 70 calculates a dose value (lgm) for each scanned image. When the software is enabled, the lgm's of each image for each examination/view used in the ADC 70 is logged into a lgm database. After a predetermined number of images of the same examination / view (usually 100), the lgm mean value and standard deviation are stored. This calculated mean becomes frozen as the reference lgm value unless continued the operator requests compilation of data. The Reference lgm value and its standard deviation can be frozen and used by the system for exposure level comparisons of future images. The lgm database will be continuously updated and the median lgm values and standard deviation of the last 100 images can be obtained for comparison and QA purposes. The lgm database and calculated data for all exams / views can be listed at user request.

Monitor calibration:

PS5000 workstation:

The PS5000 is not designed for primary diagnosis and is used for image processing, adjustments and QC functions. The image is displayed with the 12 bits contrast range re-scaled to 8 bits and a matrix size of 600×900 pixels. Zooming to full image size is possible. There are various service tools resident in the PS5000 software to display test patterns including the SMPTE pattern and other gray scale block patterns. We recommend the SMPTE phantom be used to adjust the monitor so all image areas are well visualized.

Preview Monitors:

The ADC 70 system has the capability to have up to four (4) preview monitors that can be located at remote locations such as in the x-ray room etc. A gray square test target is available in the ADC 70 digitizer and can be sent to each of the preview monitors for calibration functions. The target contains two image blocks with internal squares that differ by 5 %. Adjustments are made to ensure complete visibility of the image area.

Image Plate Dark Noise:

System diagnosis menu selections are available on the ID station. Take an erased plate and identify it as a System Diagnosis / Flat field / 400 speed class study. Process the Plate in the ADC 70 . The result should exhibit no visible signal on the hard or soft copy image.

Dimensions of Film:

This is described in the user manual. Many printing options are possible with the ADC 70. Printed image size can be made to closely match all cassette sizes. Some cassette sizes will be reduced to 95 % of nominal size when one to one imaging is requested. Multiple images on various film sizes are possible as well as reduced images on smaller film sizes. Please refer to Agfa's LR3300 laser printer users manual for details regarding printer setup and control.

Image Transmission Fidelity: (Printer Distortions, Artifacts)

A test image is available on the ADC 70 that can be sent to the laser printer for control of the image transmission and printing quality. The test film can be analyzed for the presence of any geometric distortions and artifacts. Also, the density of the top squares on the image when added to the bottom series of squares will produce a neutral uniform gray level if the image is properly printed.

ADC Auto QA Software and Test Objects (phantoms), Optional

These test phantoms are designed to facilitate continuous quality monitoring, enable corrective actions and to control the performance of the ADC 70 System. The QA system contains the following basic components.

1. **ADC Auto QA Software:**

Designed to automatically analyze the results of the phantom exposures and to graphically print or display all relative data.

2. **Spatial Test Object:**

Designed by The University of Leeds (Faxil) Department of Medical Physics based on specifications of Agfa-Gevaert. This phantom can be used with all cassette sizes.

Specifications:

Incorporated Funk Rasters	-	type 53 (0.05 mm Pb)	
Dimensions	-	400 x 330 x 9.5 mm	
Weight	-	test object = 1170 gr.	
		baseplate = 1140 gr.	
Tolerances	-	ruler	± 50 µm
		markers	± 100 µm
		Perspex	± 300 µm
Measurements	-	Fast Scan line linearity	
		SWR (horizontal & vertical)	
		Laser Beam Function - Jitter	
		Aspect Ratio	
		Scanned width	
		Plate inhomogenity (+ tube inhomogenity)	
		Artifacts	

3. **Contrast Test Object**

Specifications:

		10 step (approx. Log 0.30 per step)	
Dimensions	-	240 x 350 x 16 mm	
Cu - Filter (Leeds label)		150 x 150 x 1.5 mm	
Weight	-	2750 gr.	
Tolerances:	-	Cu-filter:	1.48 to 1.52 mm thick
		Cu-purity	99.9 %
		Thickness Step	3 %
		Purity Step	99.9 %
Measurements	-	SNR (in dB)	
		Dynamic Range	
		System sensitivity	
		System linearity	

Use a 35 x 43 cm cassette

The following technical factors are measured and monitored with Agfa's ADC QC tools and Software.

Spatial Test Object:

Exposure: Following the accurate positioning of the phantom as described in the user manual, expose with the following conditions:

- 50 kV, 20 mAs (approx. dose < 40 μGy)
- FFD = 150 cm
- Small Focus
- Collimation : Test object and cassette are to be fully exposed

Follow Cassette ID instructions as found in the user manual. The results from the spatial test object are normally printed to a laser printer. Also, a text file is created which listed the measurement results more extensively.

Spatial Resolution - Square Wave Response (SWR):

The ADC Auto QA Software module measures the modulation at subsequent segments of the two gratings incorporated into the test phantom, one horizontal the other vertical. Each segment of the grating corresponds to a different spatial frequency (between .25 and 10 line pairs per mm). The QA software computes the SWR in the range from .5 to 4.2 lp/mm. The modulation depth at the border of the grating is taken as a reference point (=100 %). The software takes into account the modulation caused by noise. The noise component is estimated from the segments between 5 and 10 lp/mm.

The SWR should be measured with the small cassette formats to determine the highest values of the system. Small cassettes, 24 x 30 and 18 x 24 cm, have the highest sampling frequency.

The resultant laser printed film displays SWR curves in the same locations as where the gratings are in the phantom, both horizontal and vertical. Acceptance levels are graphically indicated. A text display offers the SWR data for each grating step from 0.5 to 4.2 lp/mm for both horizontal and vertical SWR's.

Aspect Ratio - Geometry:

The ADC QA software measures the horizontal (h) and vertical (v) scale factors (in pixels/mm) and calculates the aspect ratio (v/h). The two measurements should be equidistant and hence, the ratio ideally should be equal to 1.

Scanned width:

The software measures the scanned width (in mm) based on the known distance between the ruler ticks of the phantom. Error indications result for phantom positioning problems or equipment variations.

Fast Scan Linearity:

The ADC QA software calculates the linearity of the laser beam deflection, based on the measured positions of the ruler ticks. The linearity is the positional sweep error (in mm) with respect to the ideal case of perfectly equidistant sampling. By convention, the sweep error is zero in the center of the image lines. In regions where the sampling distance is to small (i.e. sweep is too fast), the sweep error values will show an increasing trend. If the sampling distance is too large, the sweep error values show a decreasing trend. This data is graphically illustrated, over the entire image width, including upper and lower limits in Figure ____?

Scan Line Non-uniformity:

This is the deviation from the average (in logarithmic exposure) of the image signal along horizontal lines of a homogeneous image field. The signal deviation in each position along the line is based upon the median signal value along vertical lines over a length of 25 mm. (i.e. between 130 and 226 samples depending on the cassette format).

Note: The measured non-uniformity is not due solely to the digitizer. All system components contribute to deviation. Low frequency non-uniformity is caused by angular non-uniformity of the radiation source, small non-homogeneity of the imaging plates and non-uniform imaging optics of the scanner.

Contrast Test Object:

Data acquisition:

Accurately position the phantom and place the copper filter in the x-ray beam as described in the user manual. A kVp meter and exposure dosimeter are also required to verify exposure and kVp accuracy. After techniques satisfy the following conditions:

- 70 kV (± 1 kV) , constant kV, 12 pulse generator
- Dose = 47 μGy to the imaging plate
- Focus Film Distance = 100 cm
- Small Focus
- Collimation : Test object and cassette are to be fully exposed
- Cassette format: 35 x 43 cm
- Acquire an image and follow the cassette ID instructions in the user manual.

The results from the spatial test object are normally printed to a laser printer. A text file is also created with more extensive measurement results. The following calculations are done on a measurement window of 25 x 12 mm, of each of the 10 equidistant steps of the phantom:

Scan Average Level (SAL):

The average signal level of each window, expressed in terms of Square Root Exposure (SQRT)

Logarithmic Sensitivity Shift:

In a system that is well calibrated and the phantom has received the correct exposure the SAL value at each step will be at a fixed level. The deviation (log exposure Difference) of the measured values with respect to the known fixed levels is plotted as a graph to the left (< nominal) or right (> nominal) of the wedge steps in the film image. Tolerance ranges are indicated on the graphic image.

Dynamic Range:

This is defined as the ratio between the maximum exposure level (step 1) and the minimum exposure level (step 10. In a normally operating system the dynamic range will be 500/1 (log 2.7).

Note: With the PS5000 workstation it is possible to manually calculate the dynamic range. Using the ROI measurement options on the PS5000, the SAL of each step can be determined. The SAL is expressed as Square Root (SQRT) Values. To calculate the ratio between steps, these SQRT values must be converted to linear values (SQRT (SAL)^2 = LIN).

The ratio can be calculated by : Ratio = SQRT (SAL n)^2 / (SAL n+LIN)^2)

Signal to Noise Ratio (SNR), expressed in dB:

SNR = 10 * log (SAL / Noise) standard deviation (in SQRT [E])

The noise standard deviation is estimated on the squared differences between the pixel values in the measurement windows, and SLIDING averages in a $k \times k$ neighborhood centered around the considered pixels. The reason for using the local averages instead of the global average of the measurement window (i.e. SAL value itself) is to eliminate the effect of low frequency noise.

Signal to Noise Margin:

The amount of SNR above the acceptance level (excess dB) is plotted to the right of the wedge steps in the print image. Positive (acceptable range) and Negative (reject range) are indicated.

System Sensitivity:

The log sensitivity shift of step two is used to indicate variations of either exposure or system speed. This is displayed with tolerance levels both graphically and in text form.

Flat Field Testing:

A flat field exposure is use for the evaluation of system calibration, artifacts, mechanical status, image plate quality / wear, and optical component status.

Calibration is the equalization of the inhomogeneities of the entire optical path, including fiber optics and photomultiplier. Visual examination of the flat field image is sufficient to determine calibration.

Exposure	70 kV
	2 × 2 mAs (rotate plate 180° to offset tube "heel effect")
	130 cm FFD
	Speed class = 100

Consult users manual for proper ID station selection and guide for evaluation of flat field image.

REFERENCES??

1.

LUMISYS

LUMISCAN ACR-2000

SERVICE MANUAL

P/N 0070-715, Rev 02

JANUARY, 2000

FOREWORD

LUMISCAN ACR-2000 SERVICE MANUAL
P/N 0070-715 Rev 02

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Warranty

One (1) year parts warranty.

For more information contact:

Lumisys
225 Humboldt Ct.
Sunnyvale, CA 94089
(408)733-6565
(408)733-6567 FAX

November 1999

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INTRODUCTION

OVERVIEW

Product Features

The **LUMISCAN ACR-2000** is a precision instrument designed to scan storage phosphor screens and produce high quality x-ray images over a wide dynamic range with a high signal-to noise ratio. This is accomplished by illuminating the screen with a laser as the screen is moved perpendicular to the laser. The emitted light is collected, converted to an electrical signal and digitized to provide a 12 bit resolution image .

***High Resolution**

***High Positional Accuracy**
A precision galvanometer scanner is utilized to produce a line scan that is perpendicular to the direction of plate travel. This provides the positional accuracy required for high resolution digitizing.

***Precision Optics**
The optical system is designed to provide diffraction limited performance over the scan envelope.

***Proprietary Light Collection System**
This sets the **LUMISCAN** apart from other systems. The light collection system permits collection angles of over 150 degrees at each point, allowing measurements to be extended to low exposure areas. The collection system coupled with the detector electronics leads to a true and precise digital representation of the image information on the plate.

This document contains a basic technical overview of the **LUMISCAN ACR-2000**. The optics, digital hardware, and software subsystems are explained, as well as the systems' functionality and general user operation. Unpacking, hardware and software installation, system specifications, service adjustments and troubleshooting are also included. This document is intended for users who may need to understand the principles of operation for the **LUMISCAN ACR-2000**.

REFERENCE DOCUMENTS

LUMISCAN ACR-2000 Reader and Eraser Operator's Reference Guide	P/N 0070-711
LUMISCAN ACR-2000 Service Manual	P/N 0070-715
LUMISCAN LSDT Film Digitizer / ACR-2000 Reader Configuration Guide	P/N 0071-434

SAFETY INFORMATION

Conventions

DANGER

A **DANGER** indicates that personal injury may occur if the user does not perform the procedure correctly.

CAUTION

A **CAUTION** indicates that damage to the product may occur if the user does not perform the procedure correctly.

PRECAUTION

A **PRECAUTION** indicates that inconvenience to the user, such as loss of data, may occur if the user does not perform the procedure correctly.

NOTE

A **NOTE** indicates the information that should be called to the attention of the user.

Be sure to read and understand the installation and operating instructions before applying power to the **LUMISCAN ACR-2000**.

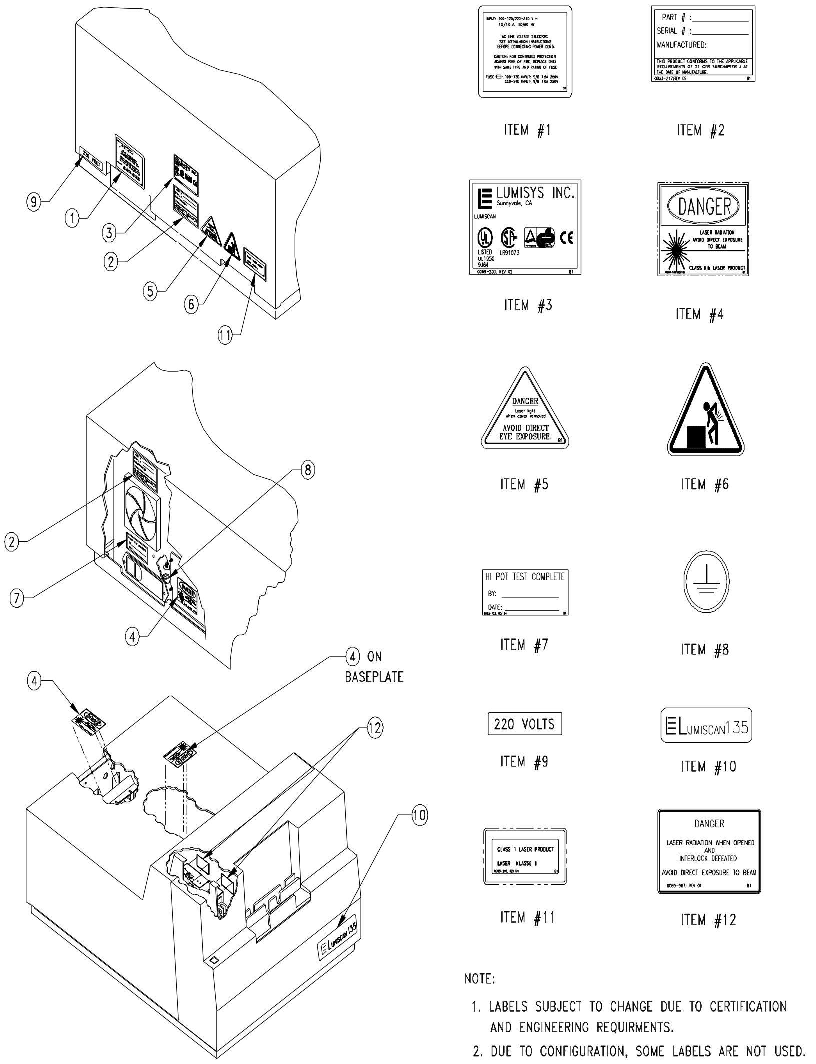
Laser Safety

The **LUMISCAN ACR-2000** incorporates a Red >15mw high-power solid-state laser diode. The covers on the **LUMISCAN ACR-2000** protect the user from direct exposure to laser light. These covers will protect a user only if they are properly installed when the system is being used. Covers must be removed and replaced by properly trained personnel. If the covers have been damaged during shipment or in usage, contact your local service representative for replacement covers.

DANGER

THIS EQUIPMENT EMPLOYS A LASER. LASER RADIATION MAY BE PRESENT IF THE LUMISCAN ACR-2000 IS OPERATED WITHOUT COVERS.
AVOID LASER BEAM. DIRECT EYE EXPOSURE TO LASER LIGHT MUST BE AVOIDED.

FIGURE I-1 LABLES


9
1
3
2
5
6
11
8
2
7
4
4
4 ON BASEPLATE
12
10
ITEM #1
PART # :
SERIAL # :
MANUFACTURED:
ITEM #2
LUMISYS INC.
Sunnyvale, CA
LUMISCAN
LISTED
UL1950
LR91073
ITEM #3
DANGER
LASER RADIATION
AVOID DIRECT EXPOSURE TO BEAM
CLASS IIIb LASER PRODUCT
ITEM #4
DANGER
AVOID DIRECT EYE EXPOSURE
ITEM #5
ITEM #6
HI POT TEST COMPLETE
BY:
DATE:
ITEM #7
ITEM #8
220 VOLTS
ITEM #9
LUMISCAN135
ITEM #10
CLASS 1 LASER PRODUCT
LASER KLASSE 1
ITEM #11
DANGER
LASER RADIATION WHEN OPENED AND INTERLOCK DEFEATED
AVOID DIRECT EXPOSURE TO BEAM
ITEM #12

NOTE:

1. LABELS SUBJECT TO CHANGE DUE TO CERTIFICATION AND ENGINEERING REQUIRMENTS.
2. DUE TO CONFIGURATION, SOME LABELS ARE NOT USED.
3. SOME LABELS ENLARGED FOR CLARITY.

Figure I-2 Label Locations

Electrical Hazards

WARNING

THIS EQUIPMENT IS OPERATED WITH HAZARDOUS VOLTAGES WHICH CAN SHOCK, BURN OR CAUSE DEATH.

This equipment must be serviced by persons properly trained and certified by **Lumisys**.

DO NOT operate the **LUMISCAN ACR-2000** with a damaged power cord.

Use of an extension cord is not recommended.

This equipment must be properly grounded and power connections inspected to insure safe operation.

FCC Notification

This equipment generates, uses, and can radiate radio frequency energy, and if not installed in accordance with the installation instructions, can cause interference with radio communications.

LUMISCAN ACR-2000 SYSTEM SPECIFICATIONS

SCAN SIZE	18 x 24 to 35 x 43 cm
PIXELS PER LINE	2048 10" to 14"
SCAN RATE	50 lines/second
GREY SCALE RESOLUTION	12 bits (4096 levels)
INTERFACE	ISA Interface Card With 16 Mbytes Memory
DIMENSIONS	20.5"W x 13"H x 27"D
POWER REQUIREMENTS	100 to 120V, 50/60 Hz, 1.5 Amps 220 to 240V, 50/60 Hz, 1.0 Amps
TEMPERATURE CONSTRAINTS	15 to 35 degrees C - operating -18 to 65 degrees C - non-operating
HUMIDITY	20 to 80% non-condensing
VIBRATION/ACCELERATION	3G Max (in shipping)
ALTITUDE	0 to 10,000 ft. - operating
WEIGHT	85 pounds (125 pounds shipping weight)

1.0 PRE-INSTALLATION

1.1 Purpose

The purpose of this section is to provide the necessary information to efficiently configure a site for the **LUMISCAN ACR-2000** pre-installation. This includes environmental, electrical, and physical parameters.

1.2 Voltage Requirements

The **LUMISCAN ACR-2000** operates at 120 VAC for domestic units. International units operate at 220/240 VAC. To change the voltage of the **LUMISCAN ACR-2000 READER**, follow the procedure in **SECTION 2.0** of the **Service Manual.** The **ACR-2000 ERASER** is permanently configured for 120VAC or 240VAC.

1.3 Environmental

There are several environmental factors to consider when installing the **LUMISCAN ACR-2000 READER**. The basic concerns are ambient light, humidity and temperature.

The ambient light in which the **LUMISCAN ACR-2000 READER** operates is extremely important. The **LUMISCAN ACR-2000 READER** is a ***DARKENED ROOM CR*** system meaning the ambient light can not exceed Exposure Value (EV) of 2. The room should be light enough to see where objects are, but no lighter. Too much ambient light during a scanning operation will darken images and introduce image artifacts.

Under ***No*** circumstances should the digitizer be placed in a darkroom with a film processor present. This will ***Void the warranty.***

The humidity and temperature limits are 20 to 80% non-condensing, and 15° to 35°C, operating, respectively.

The room should have good ventilation.

Another factor to consider prior to installing the **LUMISCAN ACR-2000** is dust. The **LUMISCAN ACR-2000** contains optics that are affected by dust. In a dusty environment, small amounts of dust and/or dirt may enter the optics module. This dust can affect image quality. To prevent this potential problem, it is recommended that the **LUMISCAN ACR-2000** be installed and operated in a clean environment.
Do not install in a room where laundry or towels are stored. These add lint and dust to the environment

Flooring should be tile and linoleum only. Carpeting or rugs should not be in the room.

1.4 Physical requirements

The **LUMISCAN ACR-2000** weighs over 75 pounds. It is important the system is placed on a table or stand that can provide adequate and level support.

1.5 Connectivity

The room needs to have a 10 Base T network connection.

2.0 LUMISCAN ACR-2000 INSTALLATION

2.1 Unpacking Instructions

NOTE

INSTALLATION SHOULD NOT BE ATTEMPTED UNLESS THE SERVICE ENGINER HAS BEEN FACTORY TRAINED

WARNING

THE LUMISCAN ACR-2000 READER WEIGHS OVER 75 POUNDS. IT REQUIRES TWO PEOPLE TO SAFELY LIFT AND MOVE IT.

THE LUMISCAN ACR-2000 READER USES A LASER FOR SCANNING. DO NOT LOOK DIRECTLY AT THE LASER LIGHT.

CAUTION

THERE ARE TWO BRACKETS ON THE BOTTOM OF THE FRONT ENCLOSURE. THEY MUST NOT BE PLACED ON THE TABLE BUT POSITIONED SO THEY HANG OVER THE TABLE TO SUPPORT THE SCREEN EXIT TRAY. THESE BRACKETS WILL BE DAMAGED IF PLACED ON THE TABLE.

2.1.1 Tools Required

A 7/16" open end wrench and a large flat blade screw driver are required.

2.1.2 Unpacking the LUMISCAN ACR-2000 READER

Using the large screw driver, remove the clamp brackets from the bottom of the crate.

Lift the crate off the pallet.

Remove the accessories box.

Remove the plastic bag protecting the system.

Using the 7/16" open end wrench, remove the 4 bolts from each corner of the pallet underneath the

LUMISCAN ACR-2000 READER.

With **TWO PEOPLE**, lift the **LUMISCAN ACR-2000 READER** off the pallet.

To install the **LUMISCAN ACR-2000 READER**, follow the **Hardware Installation Procedures**.

2.2 Hardware Installation

2.2.1 Tools Required

#1 flat-head screwdriver
#1 philips-head screwdriver

2.2.2 AC Voltage

You must verify that the **LUMISCAN ACR-2000 READER** is set up for the correct AC line voltage. This can be checked by looking at power configuration panel which is located just to the right of the power entry plug next to the on/off switch in the rear of the machine. The **LUMISCAN ACR-2000 READER** is set for 120 VAC for domestic units. See Figure 2-1.

If the **LUMISCAN ACR-2000 READER** is to be operated at **200/240VAC** line voltage configuration requires removing and inverting the Corcom fuse module, and the programming card must be changed. ***Note: disconnect power before changing line voltages or fuses.*** First remove the plastic cover/fuse module by using a small screwdriver to pry out the fuse module(See figure 2-1). Loosen the philips head screw and remove and invert the fuse block and tighten the screw. Two each 1 Amp 250V 5mm x 20mm Slo-Blo fuses should all ready be installed, if not install them. Next remove the programming card rotating it until the desired voltage is pointing inward and rotate the voltage indicator to point outward and reinsert the card. Replace the fuse module and ensure the indicator is pointing to the correct line voltage. The **LUMISCAN ACR-2000 READER** will is now set for operation.

Note

The fuse in the **LUMISCAN ACR-2000 READER** for 100/200 volt operation is a 1.5 Amp 250/75 volt Slo-Blo fuse (Lumisys Part Number 0065-513). The fuses used for 200/240 volt operation are 1.0 Amp Slo-Blo fuse (Lumisys Part Number 0068-487).

The **LUMISCAN ACR-2000 ERASER** comes either in a 120VAC model or a 240VAC model.

2.2.3 Power Cable

The **LUMISCAN ACR-2000 READER** utilizes an international IEC grade connector for the power cable. Systems are shipped with a standard NEMA 5-15 hospital grade cable. This cable requires replacement depending upon the country of installation. Insert the female end into the input power socket.

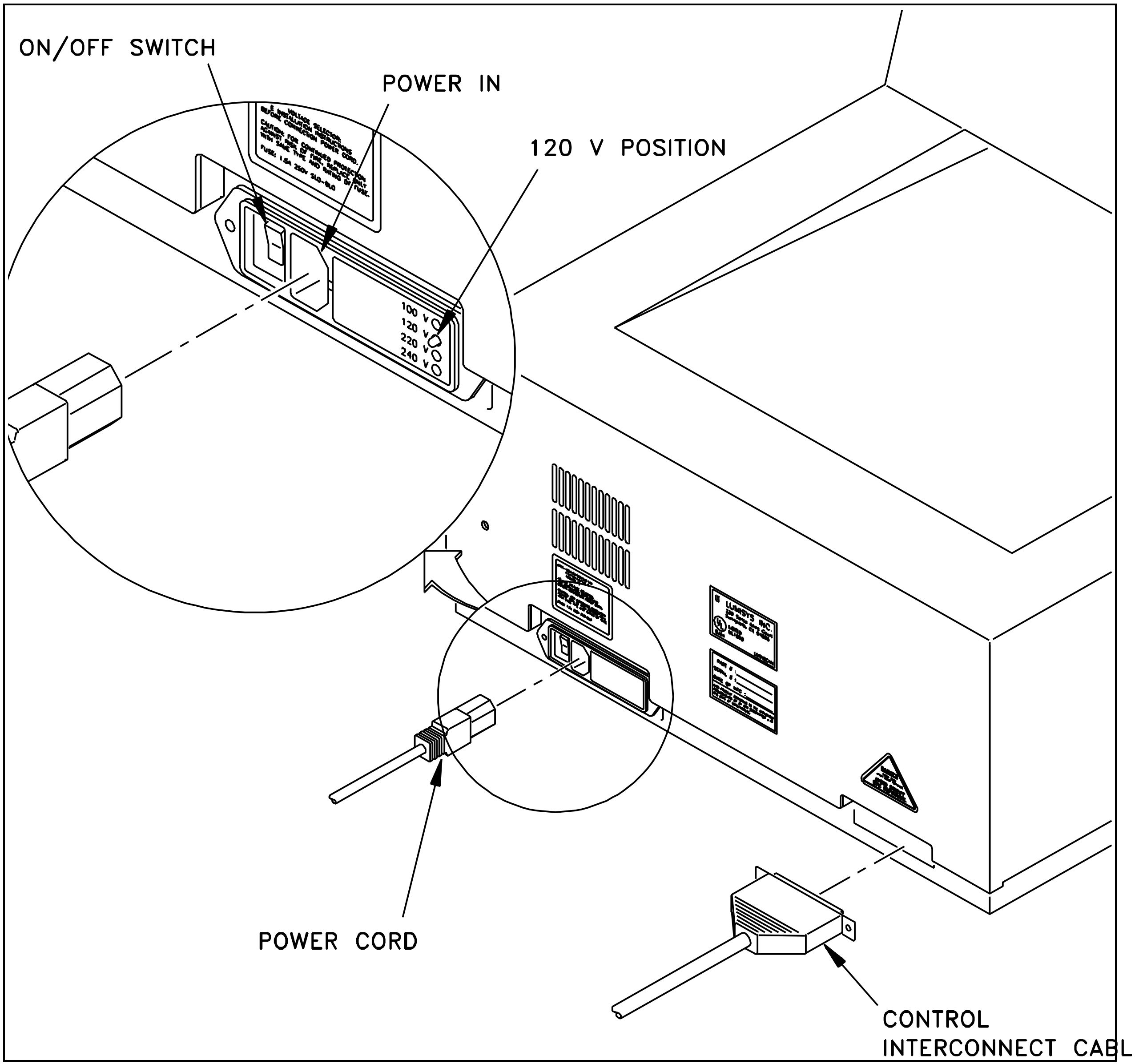

ON/OFF SWITCH
POWER IN
120 V POSITION
100 V
120 V
220 V
240 V
POWER CORD
CONTROL
INTERCONNECT CABL

Figure 2-1 Power Switch Location

2.2.4 Media Support Assembly

Fasten the Media Support Assembly to the top of the Front Enclosure.

2.2.5 Screen Exit Assembly

Place the Screen Exit Tray in the brackets on the bottom of the Front Enclosure.

2.2.6 Installation of Data Control Board (DCB)

The ACR-2000 Reader is controlled by a proprietary Lumisys Data Control Board in an IBM type PC. The DCB is 8 bit ISA. The DCB uses three resources, IRQ, Mem Seg Addr, and Base I/O Addr.

Note1: The ACR-2000 product contains a pre-configured PC workstation. It is not necessary to install the Data Control Board unless a different PC is used.

Note2: If a replacement DCB is to be installed in a PC supplied by Lumisys, the PC will likely be set to use certain resources for the DCB. These likely resources are IRQ 7, Mem Seg D800, and Base I/O 100. It is recommended to set the DCB to these resources before installation. Please consult Appendix A for the resource chart.

With power off, remove cover from the target PC or compatible(See Note below). Taking appropriate anti-static precautions, remove the **Data Control Board** from the accessory box and install it in an 8 or 16 bit ISA slot. Secure the **DCB** in the slot and replace the covers.

The **Data Control Board** is factory configured to use **IRQ 5** , I/O Addresses **100-11F** and has a 32 KByte window at hex address **D0000-D7FFF**. If these addresses conflict with your system configuration they may be changed. Please see **APPENDIX A** for instructions on how to change the IRQ level, the I/O address, or the 32 Kbyte window address.

NOTE

The minimum hardware requirements for the Host computer is as follows:

CPU: Pentium II 266MHZ
RAM: 128MB
Operating system: Windows NT 4.0 with Service Pack 4 or higher
Microsoft Internet Explorer 4.01 or higher

2.2.7 Installation of Control Interconnect Cable

Remove the **Control Interconnect Cable** (a 37 pin, Male/Male, D-Subminiature cable) from the accessories box. Connect one end to the **Data Control Board** the other end to the **LUMISCAN ACR-2000 READER** and secure both ends using a small flat blade screwdriver.

2.2.8 Installation of the ACR-2000 Eraser

Remove the ACR-2000 Eraser from its container. The ACR-2000 Eraser provides the means to return an exposed phosphor plate to its ground state and ready for the next patients exam. The eraser can be mounted on the wall by following the separate and included instructions or can be placed on a desktop near an AC outlet.

2.3 Driver Installation

To operate, the **LUMISCAN ACR-2000 READER** software requires you to have WinNT 4.0 installed on your PC and at least 2.0 megabytes of hard disk space available for the creation of a directory and transfer of files from the floppy installation disk. Additional disk space will be required to save digitized images on the disk. Most plates require 2.5 to 10.5 Mbytes of disk space to store the digital image, depending on the plate size and scanning resolution. (low quality 1K or high quality 2K)

The **LUMISCAN ACR-2000 READER** comes configured with an ISA interface. Lumisys provides host computer support software for the **LUMISCAN ACR-2000 READER** configured with the ISA interface.

2.3.1 Correction LUT Files

The Windows NT LSDT driver automatically loads a Correction LUT (CLUT) file during the driver loading process. When shipped from the factory, this file is named CLTXXXXX.DAT where XXXXX is the serial number of the reader the Correction LUT file pertains to. The CLUT file is shipped on the distribution floppy disk. This file is used to calibrate the associated reader and should be used with that reader only.

The CLUT file must be in a specific directory and its name must be specified in the LSDT section of the Registry. Since the file name is specified, multiple CLUT files may be stored in the same directory. See detailed installation instructions below.

2.3.2 DOS, Windows 3.x and Windows 95 and Windows 98 Driver Installation

To install the software, place the floppy distribution disk in drive A. From a MS-DOS prompt type ***"a:install"*** and then follow the instructions. The installation software will create a directory on the hard disk and transfer the required software from the floppy disk to the hard disk.

Copy the CLUT file (CLTXXXXX.DAT) from the floppy data disk into the root directory, C:\. Be sure to remove any and all other CLUT files from the root. They can be stored elsewhere, just not in the root.

Copy the CAL file (CALXXXXX.DAT) from the floppy data disk into the root directory, C:\. Be sure to remove any and all other CAL files from the root. They can be stored elsewhere, just not in the root.

NOTE

If, when the driver loads, no CLUT/CAL files are found or multiple CLUT/CAL files are found in the root , the driver will default to a 1:1 Correction LUT and no CAL LUT and it will audibly beep.

The device driver **LSDTVxxx.COM** (where Vxxx is the version number) must be loaded by the user for the software to work. To load the driver the user should add the command ***"lsdtvxxx"*** to the **AUTOEXEC.BAT** or from the MS-DOS command line type ***"LSDTVxxx"***. Note that in all versions of Windows, if you load the driver from a DOS session, it will only work for programs run from that DOS session, not from programs run from a desktop icon. The driver occupies approximately 17,500 decimal bytes of memory.

Also, it may be convenient to add “C:\LSDT\Tools” to your PATH statement.

NOTE

Information on driver switches used to alter the DEFAULT driver settings are described in **APPENDIX A: ACR-2000 JUMPER AND SWITCH SETTINGS**.

2.3.3 Windows NT Driver Installation

To install the software, place the floppy distribution disk in drive A. Run SETUP.EXE and follow the instructions. The installation software will create a directory on the hard disk and transfer the required software from the floppy disk to the hard disk. It will also create an NTLSDT program group and create or update various registry entries. In the NT Control Panel, a Device will be created called LSDT. The LSDT Device can be configured to start manually or automatically.

Installation types are:

"Compact"	only installs DRIVER, DLL, TOOLS, and LSEXP.EXE
"Typical"	same as "Compact"
"Custom"	by default installs everything, "Compact" plus development files (Custom recommended)

NOTE

Read the README.TXT file included on the distribution disk.

The “\SystemRoot” directory below represents the Windows NT main directory. For example, C:\WINNT (the default), C:\WINDOWS, C:\YOURNAME.

Copy the CLUT file (CLTXXXXX.DAT) from the floppy distribution disk into the directory, '\SystemRoot\system32\drivers'. Use the "LSDT for Windows NT Control Panel" (see below) to enter this filename into the LSDT section of the Registry.

Copy the CAL LUT (CALXXXXX.DAT) from the floppy distribution disk into the directory, '\SystemRoot\system32\drivers'. Use the "LSDT for Windows NT Control Panel" (see below) to enter this table into the LSDT section of the Registry.

NOTE

If the specified CLUT file is not found when the driver loads, the driver will default to a 1:1 Correction LUT and a warning message will be logged to the Event Logger.

2.3.4 Data Control Board Resources

The **Data Control Board** is factory configured to use **IRQ 5** , I/O Addresses **100-11F** and has a 32 KByte window segment at hex address **D000-D7FF**. If these addresses conflict with your system configuration they may be changed. The hardware configuration is determined by a DIP switch and an IRQ jumper on the Data Control Board. Please see **APPENDIX A** for instructions on how to change the IRQ level, the I/O address, or the 32 Kbyte window address.

The most common alternates to the default resources are IRQ 7, I/O Address 120, and Segment Address D800.

If the Data Control Board is reconfigured to use different resources, LSDT Control Panel must reflect the change also.

2.3.5 Software Installation Tips

Windows NT driver disk 2.00 and later

1. It is necessary to have a "Density Correction Lookup Table" installed to achieve accurate density tracking. This file is located on the installation floppy disk. The file format is "CLTXXXXX.DAT" where XXXXX is the serial number of the Reader. This file is installed in the "C:\SystemRoot\SYSTEM32\DRIVERS" directory. *Although more than one different file of this format can be installed, the LSDT Control Panel needs to specify which file is to be used for the particular digitizer in use.*
2. The CAL Table matching the Serial Number of the unit must be installed in the "C:\SystemRoot\SYSTEM32\DRIVERS" directory. The file is in the format "CALXXXXX.DAT".
3. Installing the LSDT NT Software will create in the NT Control Panel a Device called LSDT.
4. The Digital Control Board uses three resources that need to be free. These are Segment Address, IRQ, and Base I/O Address. One, two, or all of these resources can be changed if necessary. These settings are hardware selectable on the DCB.
5. The LSDT Control Panel needs to match the DCB resource hardware settings. The default resources are Segment Address D000, IRQ 5, and Base I/O 100. If these resources are used, it isn't necessary to change the LSDT Control Panel.
6. The most common alternate DCB resources are Segment Address D800, IRQ 7, and Base I/O 120.
7. From the LSDT Control Panel, select the CLT file matching the Serial Number of the Unit.
8. Select the appropriate CAL Table file in the LSDT Control Panel.
9. To verify the driver is installed properly, perform the following steps. Go to a COMMAND prompt. Navigate to C:\LSDT32\TOOLS. Insert a plate. Run the SCANFILE.EXE program. At the end of the scan the number of pixels per line and the total number of lines should be roughly proportional to the film dimensions. As an example, a 35cm x 43cm plate at the default resolution would be 2048 pixels per line and approximately 2500 total lines in the image. If the total number of lines significantly differs from the proper ratio there is probably a Memory Segment conflict. If the plate halts mid scan or doesn't scan there is probably a Base I/O Address conflict. If the plate goes all the way through the system without scanning there is probably an IRQ conflict.

Windows NT (prior to NT driver disk 2.00)

1. It is necessary to have a "Density Correction Lookup Table" installed to achieve accurate density tracking. This file is located on the installation floppy disk. The file format is "CLTXXXXX.DAT". This file is installed in the "C:\SystemRoot\SYSTEM32\DRIVERS" directory. *Although more than one different file of this format can be installed, the LSDT Control Panel needs to specify which file is to be used for the particular digitizer in use.*
2. The CAL Table matching the Serial Number of the unit must be installed in the "C:\SystemRoot\SYSTEM32\DRIVERS" directory. The file is in the format "CALXXXXX.DAT".
3. Installing the LSDT NT Software will create in the NT Control Panel a Device called LSDT. The LSDT Device can be set to start automatically or manually. **Until the proper DCB resources are found, it is recommended that the LSDT Device be set to Manual to prevent the PC from locking when turned on.**

4. The Digital Control Board uses three resources that need to be free. These are Segment Address, IRQ, and Base I/O Address. One, two, or all of these resources can be changed if necessary. These settings are hardware selectable on the DCB.
5. The LSDT Control Panel needs to match the DCB resource hardware settings. The default resources are Segment Address D000, IRQ 5, and Base I/O 100. If these resources are used, it isn’t necessary to change the LSDT Control Panel.
6. The most common alternate DCB resources are Segment Address D800, IRQ 7, and Base I/O 120.

To verify the driver is installed properly, perform the following steps. Go to a COMMAND prompt. Navigate to C:\NTLSDT\TOOLS. Insert a plate. Run the SCANFILE.EXE program. At the end of the scan the number of pixels per line and the total number of lines should be roughly proportional to the film dimensions. As an example, a 35cm x 43cm plate at the default resolution would be 2048 pixels per line and approximately 2500 total lines in the image. If the total number of lines significantly differs from the proper ratio there is probably a Memory Segment conflict. If the plate halts mid scan or doesn’t scan there is probably a Base I/O Address conflict. If the plate goes all the way through the system without scanning there is probably an IRQ conflict.

DOS or Windows 3.x or Windows 95/98

1. It is necessary to have a “Density Correction Lookup Table” installed to achieve accurate density tracking. This file is located on the installation floppy disk. The file format is “CLTXXXXX.DAT”. This file is installed on the C:\ root directory. *There can be only one file of this format installed at one time. Also, the file needs to match the Serial Number of the digitizer.*
2. The CAL Table matching the Serial Number of the unit must be installed in C:\ root directory. The file is in the format "CALXXXXX.DAT".
3. The TSR driver, LSDTVXXX.COM, needs to be loaded for the digitizer to operate. The driver is located in the C:\LSDT\TOOLS directory.
4. The Digital Control Board uses three resources that need to be free. These are Segment Address, IRQ, and Base I/O Address. One, two, or all of these resources can be changed if necessary. These settings are hardware selectable on the DCB.
5. The TSR driver command line needs to match the DCB resource hardware settings. The default resources are Segment Address D000, IRQ 5, and Base I/O 100. If these resources are used, it isn’t necessary to change the TSR driver command line.
6. The most common alternate DCB resources are Segment Address D800, IRQ 7, and Base I/O 120.

To verify the driver is installed properly, perform the following steps. Go to a DOS prompt. Navigate to C:\LSDT\TOOLS. Insert a film. Run the SCANFILE.EXE program. At the end of the scan the number of pixels per line and the total number of lines should be roughly proportional to the film dimensions. As an example, a 35cm x 43cm plate at the default resolution would be 2048 pixels per line and approximately 2500 total lines in the image. If the total number of lines significantly differs from the proper ratio there is probably a Memory Segment conflict. If the plate halts mid scan or doesn’t scan there is probably a Base I/O Address conflict. If the plate goes all the way through the system without scanning there is probably an IRQ conflict.

3.0 SYSTEM OPERATION

3.1 Power-Up

The power switch on the **LUMISCAN ACR-2000 READER** is located in the lower left corner of the right side panel of the scanner. Two LEDs, one above the other, are located in the lower right corner of the front panel. The top LED is labeled **Power**, while the bottom LED is labeled **SCAN**.

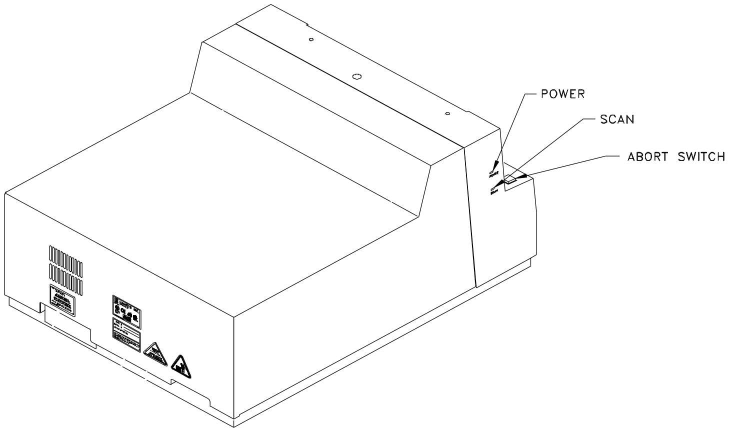


Figure 3-1 LED Locations

When power is turned on, the **Power LED** illuminates. Once the power is turned on, the PC power should also be turned on, booted and the driver installed. The scanner will emit an audible tone when the driver is installed.

NOTE

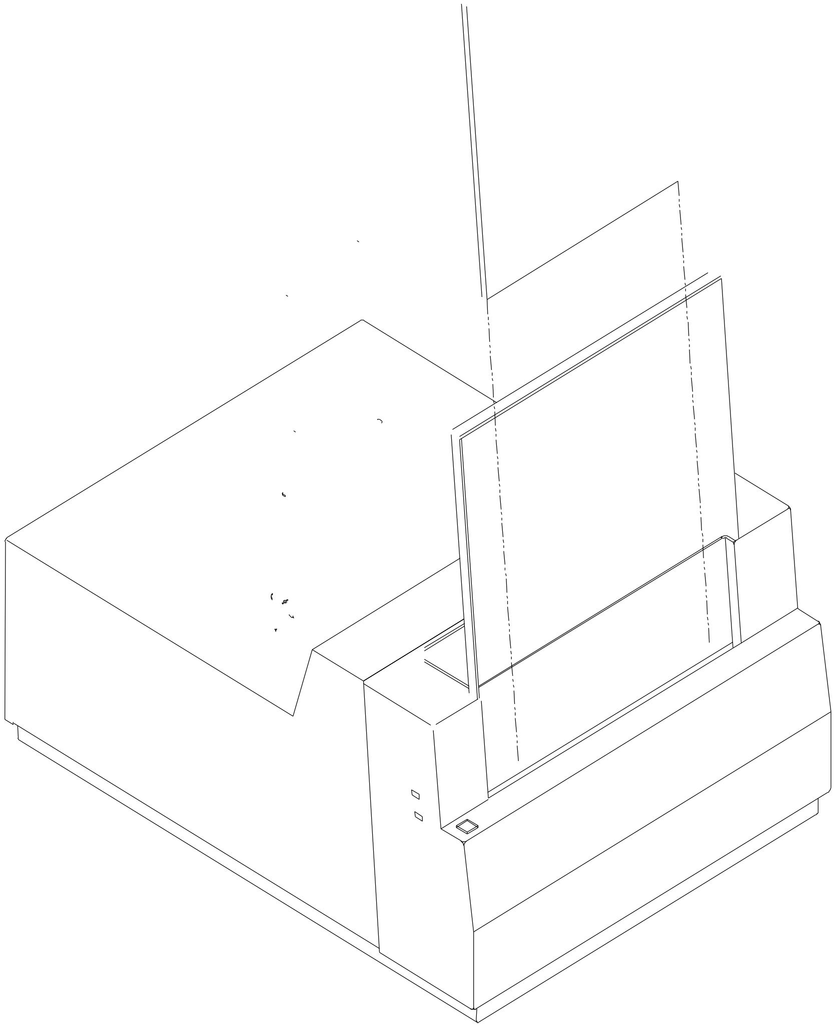
The **LUMISCAN ACR-2000 READER** should be allowed to warm up for 5 minutes prior to use in order to stabilize the system.

If the scanner is powered off and back on, the host PC driver must be stopped and restarted. This can be done using the “**lsdt**” **Device** in the **NT Control Panel**.

3.2 Plate Handling and Loading

Processed Phosphor Plates that are to be scanned should be handled carefully to avoid introducing scratches, fingerprints and/or static.

The physical process by which storage phosphors work does not change or, “wear out”, over time. Consequently, the lifetime of the storage phosphor screens is dependent on how carefully they are handled. Dust, fingerprints and scratches on the plate may be visible in the x-ray images and degrade their quality. For plate cleaning instructions, refer to Chapter 6.



Handle plates with powder-free latex gloves.

Clean plates every day or after every 10 scans. Use Anhydrous Ethyl Alcohol applied with laboratory grade lint free paper towels.

Clean the input guide and output tray with anti-static guard spray every day.

3.3 Technique

The Lumisys ACR-2000 is a roughly 200 speed system.

If only CR images are acquired, Phototimers should be adjusted for CR exposures. This is because the speed of the system and because CR cassettes attenuate x-rays differently than conventional screen-film cassettes.

3.4 Scanning A Plate

Once a plate has been placed into the image plate-input guide, the user may initiate a scan. Once started the image plate will be moved into position, the edges found and the image plate digitized.

To digitize a plate you may use the DI-2000 Acquisition Application which is installed on the ACR-2000 Workstation. Please reference the DI-2000 Users Reference Guide which is located in the C:\DI-2000 directory.

You may also use the sample scanning program called "SCANFILE.EXE", which is located in the “C:\LSDT32\TOOLS” directory.

> From the command prompt type "SCANFILE <cr>".
>
> A image plate will be digitized in a Lumisys format using all default parameters and the results placed in a file called LSDT.IMG.

WARNING

THIS EQUIPMENT EMPLOYS A LASER. LASER RADIATION MAY BE PRESENT IF THE LUMISCAN ACR-2000 READER IS OPERATED WITHOUT COVERS.

AVOID LASER BEAM. DIRECT EYE EXPOSURE TO LASER LIGHT MUST BE AVOIDED.

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4.0 THEORY OF OPERATION

4.1 Product Overview

The **LUMISCAN ACR-2000 READER** is a single-image plate laser scanner designed to scan and digitize the latent image from medical storage-phosphor image plates. The system is based on a fixed size scanning spot and can scan up to 2048 pixels across image plates of 18 to 35 cm in width. This is achieved with a high intensity spot of light derived from a high-power red laser diode which is scanned across the image plate surface as the image plate is moved perpendicular to the beam scan. The stimulated light is collected and digitized to provide an image file that can be stored on disk, transmitted to other systems for processing and manipulation, archived, and/or printed back film.

The **LUMISCAN ACR-2000 READER** is a basic scanner with no image plate handling and is intended to be used in a ***darkened room environment***. The image plate must be removed from the cassette and placed into the feed slot in order to be scanned. When the scan is complete the image plate must be removed from the exit tray and erased by placing into the external eraser, then reloaded into its cassette for the next use.

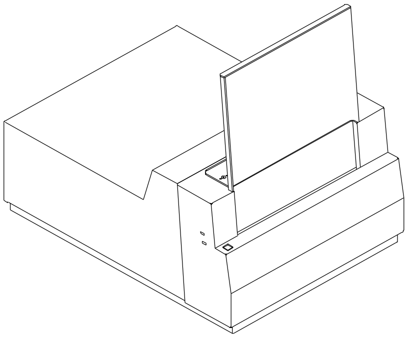

Figure 4-1 Lumiscan ACR-2000 READER

4.2 System Configuration

The configuration of the **LUMISCAN ACR-2000 READER** includes optics, electrical and power supply assemblies, PCAs for scanner control and data acquisition, and a plate transport assembly.

4.3 Optical Beam Path

The **READER** contains a laser, laser power supply, fixed optics and mirrors, a scanning galvanometer, light detection system and a electronics subsystem for control.

The **READER** uses a red, high-power solid-state laser diode (about 35 mw at 658 nm) as the beam source. The laser diode energy is coupled into a single-mode fiber which is then focused through a lens to produce a very high-quality spot. The beam is deflected by a galvanometer scanner to produce the sweep. The folding mirror bends the beam so as to sweep the beam horizontally across the image plate as the image plate travels vertically. See Figure 4-2.

The beam passes through the integrating collection cylinder and strikes the phosphor surface of the image plate. The red light striking the image plate stimulates blue emission from the image plate in proportion to the X-ray energy stored in the image plate as a result of the exposure. This blue light is collected by the integrating cylinder. The red light is blocked from reaching the photomultiplier tubes by blue glass filters. The collected blue light is detected by photomultiplier tubes, which convert the photons into a signal. This signal is then logarithmically amplified, corrected for spatial variations in the system sensitivity across the width of the screen, and then digitized by an A/D converter.

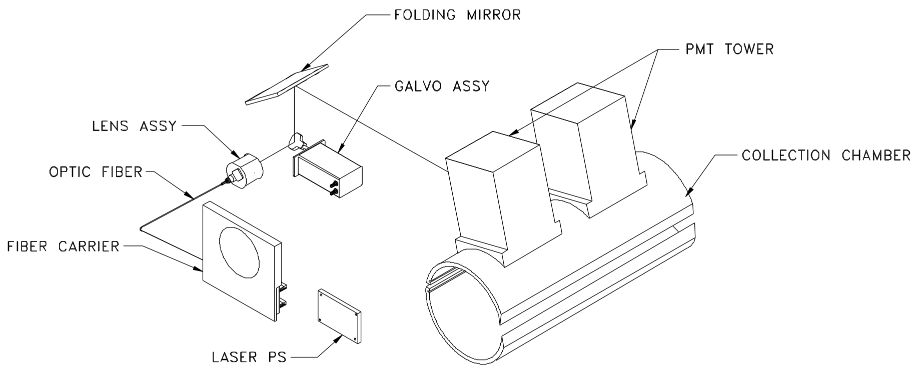

Figure 4-2 LUMISCAN ACR-2000 READER Optical Beam Path

4.4 Digital and Electrical Systems

The electrical subsystem of the **LUMISCAN ACR-2000 READER** consists of the **Data Control Board**, (DCB), that is located in a PC-type host computer an interconnecting cable to the **LUMISCAN**, and the scanner, which houses six printed circuit boards. These include:

Data Acquisition Board (DACQ),
PMT PreAmp Board,
Galvanometer Board,
Indicator Board.
Indicator/ff Interface Board
Reference LED Board

4.4.1 Data Control Board

All operations are controlled by the **Data Control Board** via means of control registers. Although some of these registers are physically located on the Data Acquisition Board, they are accessed through the Data Control Board. Once a scan is initiated, data acquisition is automatic, requiring no intervention until the image has been written into image memory on the Data Control Board. Image data can be transferred out of image memory during or after image acquisition. The Data Control Board receives its power from the host computer. No power is transmitted over the interconnect cable.

4.4.2 Data Acquisition Board

The **Data Acquisition Board** performs all the signal conditioning and data acquisition functions, including calibration and lookup table functions.

4.4.3 PMT PreAmp Board

The **PMT PreAmp Board** contains the first stage preamplifier. This board provides power connection, a high voltage divider network for the PMT tubes and a first stage amplifier for the PMT signals.

4.4.4 Galvanometer Board

The **Galvo board** contains a high-accuracy feedback servo amplifier for controlling the position of a mirror mounted on the shaft of a scanning galvanometer. Position feedback is from a sensor integral to the galvo. The galvo motor shaft oscillates back and forth through an arc of approximately 30 degrees at a rate of 50Hz. A small mirror attached to the shaft intercepts the static laser beam and sweeps (scans) it across the width of the image plate. It important that the Galvanometer Board be adjusted so that the beam scans across the plate at a consistent speed. Proper performance of the Galvo PCB is dependent upon the adjustment of several of its potentiometers.

4.4.5 Indicator Board

The **Indicator Board** contains two LED indicator lamps which are used to signal scanner power ON and SCAN status. The SCAN indicator is turned on only while a scan is in process; it also blinks whenever the plate is in the optical path.

4.4.6 Indicator/FF Interface Board

The **Indicator/FF Interface Board** provides an adjustable drive circuit for the Reference LED Board.

4.4.7 Reference LED Board

The **Reference LED Board** provides a means of mounting the blue reference LED and a connector. The blue LED provides a consistent reference signal for purposes of self-alignment by the electronics.

4.4.8 Power Distribution

The **ACR-2000 READER** contains four integral power supplies. One is a high voltage supply for the PMTs. A triple output linear supply provides ± 12 volts and +5 volts. One dual linear ± 15 volt supply and one dual linear ± 12 volt supply. The ± 15 and the ± 12 volt power supplies are identical except for jumper configuration.

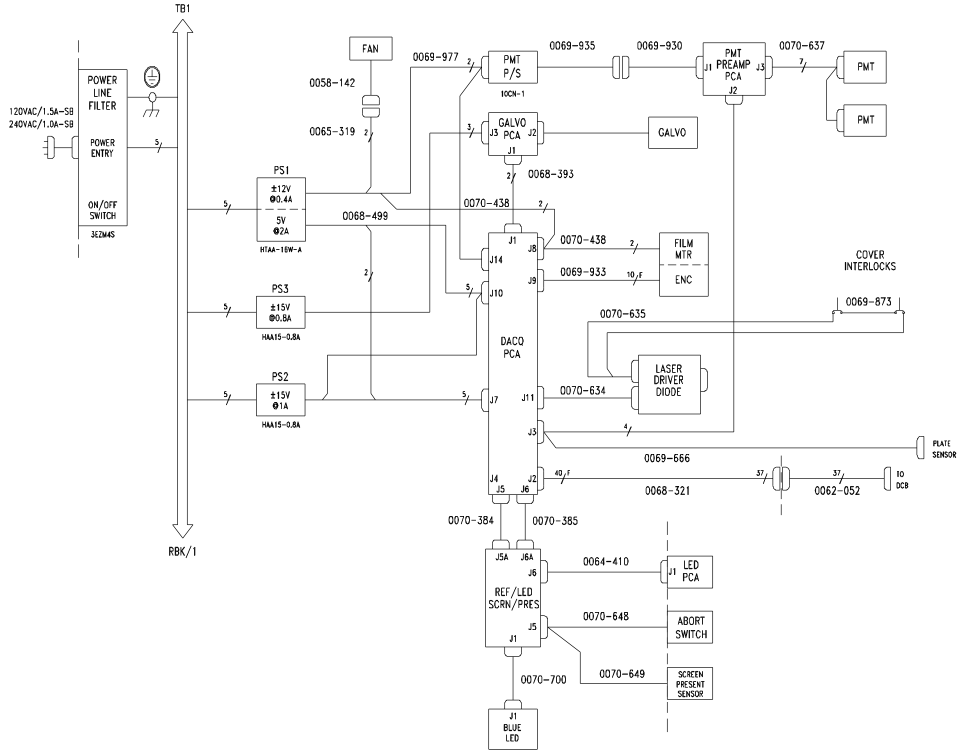
TB1
RBK/1
POWER LINE FILTER
POWER ENTRY
ON/OFF SWITCH
3EZM4S
120VAC/1.5A-SB
240VAC/1.0A-SB
5
FAN
0058-142
0065-319
2
PS1
±12V @0.4A
5V @2A
HTAA-16W-A
PS3
±15V @0.8A
HAA15-0.8A
PS2
±15V @1A
HAA15-0.8A
0069-977
0068-499
PMT P/S
10CN-1
0069-935
0069-930
PMT PREAMP PCA
J1
J2
J3
0070-637
7
PMT
PMT
GALVO PCA
J3
J2
J1
3
GALVO
0068-393
0070-438
2
DACQ PCA
J1
J8
J14
J9
J10
J7
J11
J3
J2
J4
J5
J6
0070-438
FILM MTR
ENC
0069-933
10 F
COVER INTERLOCKS
0069-873
0070-635
LASER DRIVER DIODE
0070-634
4
0069-666
PLATE SENSOR
40 F
0068-321
37
0062-052
TO DCB
0070-384
0070-385
J5A
J6A
REF/LED SCRN/PRES
0064-410
LED PCA
0070-648
ABORT SWITCH
0070-649
SCREEN PRESENT SENSOR
0070-700
J1 BLUE LED

Figure 4-3 LUMISCAN ACR-2000 READER Power and Electrical System

The Digital Control Board receives its power from the host computer. No power is transmitted over the interconnect cable.

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4.5 Sub-System Operation

4.5.1 DATA CONTROL BOARD (DCB)

The DCB is a standard size PC/XT board occupying 32K bytes of memory space and 24 bytes of I/O space. It supports 8-bit data transfers only and has multiple interrupt capability. The physical memory consists of a single, 72-pin SIMM with 16MB.

Image memory is accessible through a 32KB window. This window can be positioned on any 32KB boundary within the standard 1MB DOS address space by means of five DIP switches on the DCB. Memory page selection is accomplished through a Bank register.

The image memory is accessible at all times including during image acquisition. An arbiter controls access, giving the data writes priority over bus access. If necessary the PC bus IOCHRDY signal is asserted to delay the bus access. The image memory should never be written to from the bus during image acquisition.

During image acquisition a separate 24-bit counter selects sequential byte addresses for each data write; counting always starts at address zero. Address counting is only enabled when SCAN is true, and is reset to 0 when SCAN changes from false to true. The counter can be read at any time.

The control registers are mapped into the I/O addresses 100 hex through 117. These locations are fixed and can be changed only by changing the firmware. The DCB allows the selection of three alternate mapping of the I/O registers by means of a DIP switch.

In addition to image memory there are 64KB of memory on the Data Acquisition board which are accessible through the DCB. This memory is where the calibration and lookup tables are located and is fully R/W accessible, but only while not scanning. Access is sequential through a 16-bit I/O register. The memory is organized on the Data Acquisition board as eight tables of 4K x 16 bits each. The sequential access can begin at the beginning of any one of the eight tables by means of a 3-bit LUT bank select field and an Autoincrement Reset bit. Accesses can extend beyond the selected bank; the bank register will autoincrement also.

The DCB can interrupt at levels IRQ3 through IRQ7 (jumper selectable). There are four possible interrupt sources; each one can be separately enabled and cleared.

Control During Scanning

During the scanning process the DCB generates the timing and synchronization signals and transfers the image data into image memory as it becomes available. There are three clock generators and three counters: Scan Clock, Film Clock, Pixel Clock, Delay to 1st Pixel count, Pixels per Line count, and Lines per Image count. These are each described briefly below.

The **Scan Clock** is a continuous clock signal derived by dividing 10Mhz. It is used to control the line scan repetition rate and to synchronize the beginning of each scan sweep (Start of scan, or SOS). The actual linear rate during each sweep is controlled by the Data Acquisition board. For the **135** the Scan clock is set for a 50 Hz scan rate and should never be changed.

The **Film clock** is a continuous clock signal derived by dividing 10Mhz. It is used as the reference for a frequency-controlled servo motor driver which controls the film transport motor. The plate speed is directly proportional to this frequency.

The **Pixel Clock** is a gated trigger signal derived from 40Mhz. The trigger signal is sent to the DACQ during each scan line after the completion of the Delay to 1st Pixel count and until the completion of the Pixels per Line count.

The **Delay to 1st Pixel** counter counts the Pixel clocks, beginning at SOS (Start of Scan) and terminating when its preset count is reached.

The **Pixels per Line** counter is enabled at the termination of the Delay to 1st pixel count and counts Pixel clocks, terminating when its preset count is reached. If enabled an interrupt request will be generated at count termination.

The **Lines per Image** counter is enabled at the beginning of a scan and is incremented at the end of each scan line, terminating when its preset count is reached. If enabled an interrupt request will be generated at count termination. The usual value for this counter is 65,535 (maximum), which effectively disables this control and permits the Isfilm (plate present status) signal to be used to control acquisition.

Interrupt Requests

There are four possible sources for interrupt requests by the DCB: Last pixel in line, Last line in image, Change in Isfilm (film entering or leaving optical path), and Event 0, which is used for the Abort switch. Each can be independently enabled and cleared.

4.5.2 DATA ACQUISITION BOARD (DACQ)

The DACQ board performs all of the signal conditioning and data acquisition functions, including calibration and output table lookup. In addition it generates the Galvo sweep control waveform and provides the Film Motor control and drive.

The DACQ is optimized for digitizing image plates up to 14" wide with a resolution of 2048 pixels/line (146 pixels/inch) and can accommodate increased resolutions with smaller plates (e.g. 256 pixels/inch across a 8" image plate

Most of the digital logic on the DACQ board is contained in two large Programmable Logic Devices and a Digital Signal Processor. These are ICs which are SRAM-based and must be downloaded with code before they become functional. The DSP downloads or boots at power-on and each time a DACQ function is initiated. However at power-on and after the DSP boots, it then also downloads the two PLD's with their code. If for some reason the download fails to complete, the board will be nonfunctional.

Signal Conditioning

The analog signal path consists of a logarithmic amplifier. The log amp is of a special type that does not depend on a semiconductor junction but rather a resistor ladder network. It has inherently high stability, dynamic range and bandwidth and depends only on resistor values for accuracy. In addition there is a proprietary self-adjustment circuit which is controlled by the DSP and acts to maintain the low-level signal accuracy.

Start/end of Film Detection

The Start/End of Film (ISFILM) detector is a photodetector which is located at the cylinder slot such that it is in the path of the laser sweep when there is no image plate present, which results in a pulse signal. This signal is blocked while the image plate is being scanned; ISFILM is defined as the absence of this pulse. Note that if the laser is not on or the sweep is misaligned such that it does not strike the detector then this will be interpreted as ISFILM being true.

Acquisition Control

The acquisition process begins with the initiation of an A/D sample output of the log amplifier. Control is primarily by the DSP device (DQDSP.DSP), in conjunction with PLDs (DQCTRL.TDF and DQDSPIF.TDF). A pixel acquisition sequence is initiated by each PIXTRIG signal from the Data Control Board. The function performed for each pixel depends on the Mode which is selected in the DACQ CSR. During acquisition, the functions may include from one to three lookup table steps and a check of the data against upper and lower limits.

In all modes the acquisition process ends with the writing of data into the output register and assertion of the signal DATAVAIL to the DCB. The DCB then transfers the data into the image memory depending on the following; the Mode, the state of ISFILM, the state of the Pixel counter and the state of the Line counter.

Calibration and Table Lookup

The three possible Lookup table functions are: Correction LUT, Calibration LUT and Output LUT.

The **Correction LUT** is used to correct any deviation of the logarithmic amplifier from a true logarithmic characteristic. It is applied immediately after the A/D results are read.

The **Calibration LUT** is used to compensate for variations in the sensitivity of the system with respect to the horizontal scan. It is generated by scanning a uniformly exposed 14" wide image plate, averaging a number of lines and normalizing the data. This forms a reference look up table with a value for each pixel in a line. This data is truncated and scaled the provide the calibration curve for any size image plate scanned at any allowable number of pixels per line. During acquisition each pixel value from the A/D is added to its corresponding calibration LUT value. Since this addition is of the log of the signals the effect is the same as multiplying the pre-log signal by a scaling factor.

The **Output LUT** is for user use and depends on the application. The default table is a 1:1 Lookup Table. It can be replaced by an inverse 1:1, a 12-bit to 8-bit mapping, or any other desired function.

Automatic Gain Adjustment

Automatic Gain Control is used to compensate for reduction in sensitivity of the PMT detectors due to age. Automatic gain adjustment (AGC) is performed whenever a DACQ mode 5 command is received. The DACQ Mode 5 is a special mode exclusively for the automatic adjustment of the output gain of the PMTs, as well as automatic adjustment of the log amplifier input offset voltage. The only data generated are the results of the adjustments. The appropriate enable bits must be set in the DACQ CSR for the adjustments to take place, or else the adjustments will be set to null or minimum. When the AGC enable bit is set the HV register specifies the gain to adjust to. The gain may be set to a calibrated level over a range of two decades (2000 counts).

Because there is no signal without the presence of a exposed phosphor image plate a special blue reference LED is incorporated into the collection cylinder which is under firmware and software control. During setup the LED is adjusted for a calibrated, constant light output. Then, during the AGC process the blue LED is turned on and the PMT high voltage is changed so as to produce the desired A/D output. Because the laser produces no signal the galvanometer need not be scanning.

X Only and XY Pixel Averaging Modes

The **ACR-2000 READER** Data Acquisition board is capable of averaging pixel values together, either in X only or in both X and Y. The mode bits are selected in the DACQ CSR. In X-only mode one data value is produced for each two pixel clocks (one DATAVAIL per two PIXTRIGs). The data value is the average of two samples. Thus the amount of data is reduced by two, and the film speed should double in order to maintain a 1:1 pixel aspect ratio.

In XY averaging mode two lines are averaged in addition to the pixel averaging described above. Thus each data value is the average of four adjacent pixels (2x2) and the amount of data is reduced by four. In this case the film speed is the same as for no averaging.

Galvo Control

Control of the galvo in the **ACR-2000 READER** is different from control in the LS100/200 series in that the basic sweep and retrace times are not programmable. These parameters are fixed in firmware; the PLD must be changed in order to change these parameters. The present settings are 480 kHz up clock (8.53ms up ramp) and step return to start (no down ramp).

The SCANCLK signal from the Data Control Board no longer controls the sweep speed. The sweep speed is now fixed within the generation circuit (DQFMGV.GDF) and can be changed only by changing the firmware. The SCANCLK signal now controls the repetition, or line, rate. This is fixed for each model and should never be changed.
For the **ACR-2000 READER** the Scanclk frequency is 10,000,000/25000 = 400Hz. This signal is always sent by the DCB; active galvo scanning is enabled by the Galvo Enable bit in the DACQ CSR.

This is divided by 8 in DQFMGV.GDF, which generates the SOS signal. Thus the scan synchronization begins here. The SOS signal initiates a galvo sweep and also is sent back to the DCB to begin the line acquisition sequence.

The Galvo board is now a more standard servo control amplifier and the interface is simpler. The sweep is linearized with a lookup table (GLVLUT.DAT) which converts the linear stairstep output from the generation circuit into an S-shaped waveform. The amplitude and DC offset of the output signal can be varied by two on-board potentiometers.

Galvo Rest Positions

If the SCANCLK signal is present and the GLVENB bit is set in the DACQ CSR, then the galvo sweep signal will be generated, causing the galvo to sweep. If the GIVENB bit is cleared the galvo will stop sweeping and will take a static position according the settings of the "PARK" switched and the "CTR" jumper. If the CTR jumper is installed the position will be at count = 2048, which is the electrical midpoint of the sweep. This is irrespective of the setting of the PARK switches.

If the CTR jumper is off and the GIVENB bit is cleared then the position will be according the PARK switches, which consist of 6 DIP switches. The position will be equal to the switch value 0 through 4032. (0 through 63 times 64). The beam can be parked at any location within 64 counts by setting the switches.

Film Transport Motor Control

The **ACR-2000 READER** film transport motor is a precision DC motor with a 256-count encoder. The control for this motor is on the Data Acquisition board. It is a frequency-controlled servo amplifier, with the reference frequency, FILMCLK, coming from the DCB. The linear plate speed is directly proportional to the FILMCLK frequency. As with the galvanometer control this signal is always being generated by the DCB; motor drive and direction are controlled by two DCB CSR bits, Motor Enable and Film Reverse. There are no adjustments to the plate transport motor control circuit.

Speed is set by an input clock rate between 9khz and 16khz, which accommodates the necessary range of plate speeds. When the Motor Enable bit is set to 1, the input clock signal is compared with a motor encoder signal. The input clock signal causes a counter to count up, the encoder rate signal causes the same counter to count down. The residual count is converted to an analog voltage via a Digital to Analog Converter to drive the motor. When the motor(encoder) rate matches the desired input clock rate, zero servo error and speed stability is attained. Plate reversal is performed by changing the polarity of the servo signal when the motor reverse signal is activated.

Interface to the Data Control Board

The interface between the DCB and the DACQ is by a 37-conductor cable. The signals include a bi-directional 8-bit data bus, status signals from the DACQ, and control signals from the DCB.

The DACQ is a slave in all data transfers. There are two types of data transfer: DACQ register R/W and DCB image memory write during data acquisition. During data acquisition the DACQ signals the DCB when a data word is available (DATAVAIL) and then the DCB reads the data a byte at a time over the interconnect, writing it to the image memory with the autoincrement address counter setting the address. The signal (SCAN) must be true for data transfer to occur, which is automatic. Also the status signal ISFILM must be true in order for the DACQ to assert DATAVAIL.

DACQ register access includes the DACQ CSR and the Cal/LUT autoincrement memory SCAN must be false for this to occur.

4.5.3 PMT PREAMPLIFIER

The preamplifier is the interface between the PMT receiving the stimulated light from the collection chamber and the log processing circuits in the Data Acquisition PCA. The preamplifier serves as a current to voltage converter between these two assemblies.

The preamplifier is a single integrated amplifier with the input power and common return provided from the Data Acquisition PCA. The input power is filtered at the amplifier and reverse bias diodes are provided to protect the circuit against improper connections of the input power. High voltage from a PMT supply is divided in 10 equal differential voltages and used to bias the cathode, grid, and 8 dynodes of the PMT.

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5.0 SERVICE ADJUSTMENTS

This section covers the **LUMISCAN ACR-2000 READER** components that can be adjusted in the field.

The following equipment is required for any alignment or adjustment performed in this section of the service manual.

Requirements

HARDWARE REQUIRED

Computer with keyboard and monitor
Interconnect cable, PN 0062-052
Data Control PCA (DCB)
Oscilloscope, 50 Mhz, dual trace or better
Digital Volt Meter(DVM)
Imaging workstation
DVM
Laser power meter, Photodyne or equivalent
Storage phosphor image plates, 14 x 17inches, Agfa, Kodak or Fuji
Interlock switch cheat keys, 2 each
X-ray system capable of 85 kVp at 8 mAs
X-Ray exposure meter (capable of discerning 0.05 milliRads)
Copper step wedge, .020” x 8 steps
Copper plate (1mm thick)
Set of Standard Screw Drivers(Flat blade, philips)
Small Screw Driver(Tweaker)
Hex Driver Set (5/16 thru .050)
Photographic Dark Cloth Cover
Diagnostics
Galvo Linearity Pattern P/N 0070-966

SOFTWARE REQUIRED

Lumisys diagnostic and calibration tools must be available. These are typically found in the C:\LSDT32\TOOLS directory. The Data Acquisition (DACQ) board must also have its associated CLUT file available, as generated during board-level testing.

WARNING ACR-2000 READER

Working with and around X-ray equipment and high-power lasers present risks if proper precautions are not taken. The X-ray equipment is housed in a lead-lined room. Never turn the X-ray on unless all personnel are outside of the room and the door is closed. Perform the following steps in a darkened or dimly lighted room so as not to damage the PMT.

5.2 Optics

This procedure contains complete field optical alignment instructions for the **LUMISCAN**.

NOTE

Laser light is present. Observe all warnings and cautions listed in the Introduction, Installation and Maintenance sections of this manual.

Any component change in the optical path will probably require re-alignment and adjustment of all subsequent elements, from that point on, to the PMT sub-system.

All optical surfaces are sensitive and delicate. Follow the **Optics Cleaning** instructions in this Section of the manual.

5.2.1 Optical Adjustments

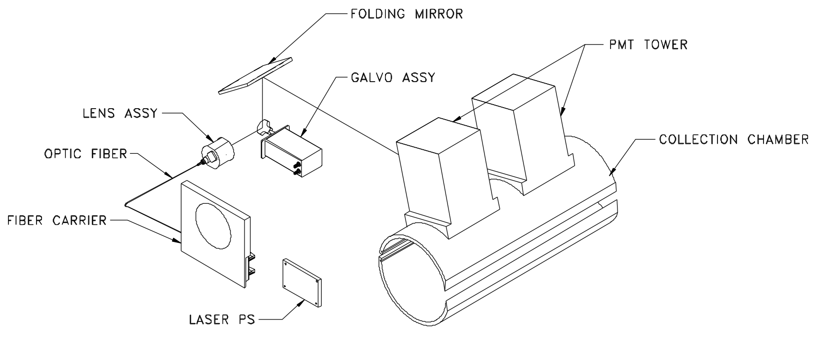
Optical Adjustments NOTE

The following alignment procedures are *not required* unless a component used in the procedure has been replaced. Alignment should not be attempted unless the service engineer has been factory trained.

The following is a list of the Optical adjustments. See Figure 5-1.

Laser Diode Module assembly
Galvo Scanner
Folding Mirror

Remove the **LUMISCAN** main cover to gain access to the Optics. (Refer to **Section 8.0** of this manual).



1. Laser Light Verification

Install the Interlock Key to allow operation of the Laser with the cover off. Remove the optics cover on the back panel. Turn on the ACR-2000 Reader. Observe that the beam is projecting onto the Galvo Mirror. If the power is on and the Interlock Key is installed and there is no Laser light, the Laser Module is suspect.

2. Folding Mirror

Disconnect the **J3** power cable to the Galvo PCA. Ensure that the beam is projecting to the center of the Light Collection Chamber +/- **0.5** inches. If not, rotate the Galvo Motor or the Galvo Mirror to achieve center. Re-connect the Galvo PCA power. Go to the command prompt. Navigate to the Lumisys "tools" directory. Start the **DDT** menu. Start the Galvo by selecting option **20** from the **DDT** menu. Adjust the height and the tilt adjustment screws that are located on the folding mirror until the beam is horizontally centered and vertically level in the Light Collection Chamber opening. Remove Galvo PCA power at **J3**. If the beam is not horizontally centered, start step **2** over again.

3. Plate Detector Alignment

Note: This adjustment applies ***only*** *to readers with Data Acquisition PCA P/N's 0070-735 and below. This adjustment is* ***not*** *necessary for readers with Data Acquisition PCA P/N's 0071-592 and above.*
Go to the command prompt. Navigate to the Lumisys "tools" directory. Start the **DDT** menu. Select option **20**. Press "**I**" to measure the "Isfilm" signal. Press "**P**" to plot the "Isfilm" signal. You should see three spikes approximately 1600 in amplitude. If these spikes are not seen, the beam is not hitting the three detectors. Use the roof mirror to raise or lower the beam until all three spikes are visible.

5.3 Scan Linearity Adjustment

NOTE

This Adjustment Must be done in a Darkened Room

NOTE

Adjustment of the Scan Linearity is rarely necessary. For various reasons, the Linearity Test can sometimes provide a false indication of failure. Test results which are slight out of tolerance are probably genuine. Test results which are far out of tolerance are likely false. The most common reason for false Test results is too much ambient light leaking into the unit. Be sure to verify that the Scan Linearity is failing before making any adjustments

This adjustment will assure that the reading of a single line of data occurs within the most linear region of a given Galvo motor sweep, and that the edges of the film do not fall outside of the scan range.

The test pattern used in this adjustment has 14 evenly spaced bars of equal width. **R45 Damping** and **R47 Servo Gain** on the **Galvo PCA** are used to adjust the rate of beam movement across the 14 bars so that the number of pixel samples on each bar is the same. If the beam moves too slowly across a bar the number of pixel samples will be too high. This error is quantified by the **LNADJDT** program as **CAL+**. Conversely, too few pixel samples result in **CAL-** error. **R58 Galvo Offset** is used to position the beam so that the 14 bars are centered in the beam span **.** **R59 Galvo Span** is used to adjust the beam span so that the sum of the 14 bar widths is a specified value called **Sum of Deltas**, which is the sum of the pixel samples of the 14 bars. The field specification for these parameters is as follows.

Nominal Parameters
Cal + error: less than **2**%
Cal - error: less than **2**%
Sum of Deltas: 3902 ± 1
Distance to first edge: 86 ± 1

Preferred Parameters
Cal + error: less than **3**%
Cal - error: less than **3**%
Sum of Deltas: 3902 ± 8
Distance to first edge: 86 ± 3

Allowable Parameters
Cal + error: less than **5**%
Cal - error: less than **5**%
Sum of Deltas: 3902 ± 20
Distance to first edge: 86 ± 7

5.3.1 The room lights should be dim and the unit covered to minimize stray light.

5.3.2 Place the 14” Linearity Adjust Pattern (P/N 0070-966) in the input slot with the vertical lines facing the unit and the widest red bar towards the abort button.

5.3.3 From the “tools” directory, enter LNADJDT at the command prompt. Enter the Serial Number of the reader. Press <Enter> to continue. When prompted for Lines to Skip, press <Enter>. Observe the following screen display.

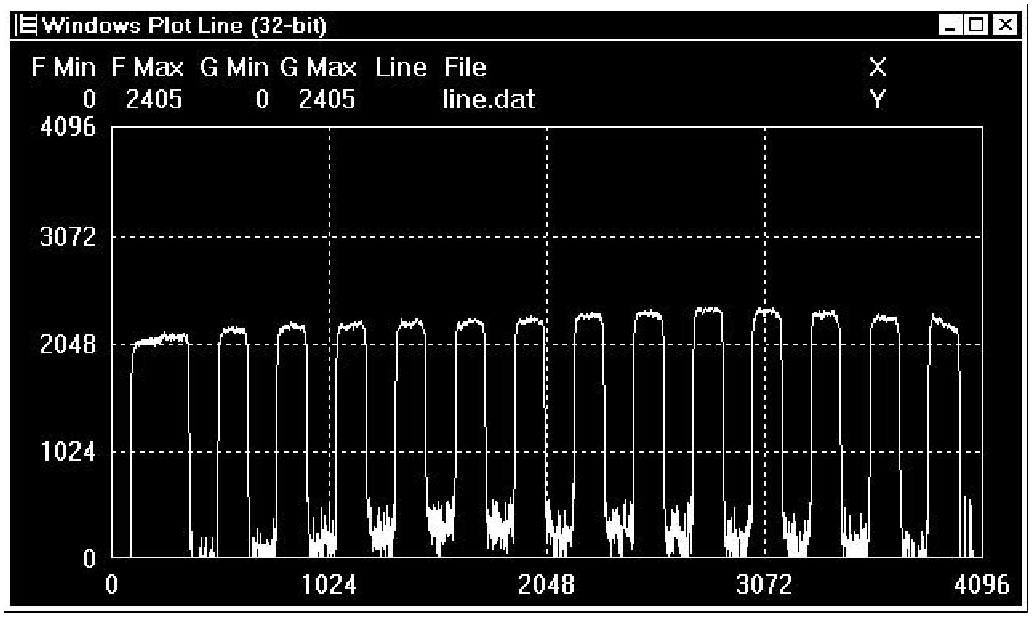
```
LINEARITY ADJUST TEST,  Lumisys, Inc. (c) 1994
SN: xxxx  Model: LSxx  Target Delta sum: 3902 1st Edge: 86

Delta:   276    277    278   277    280   279   281   280    280    279   280   278   278   279
Marks:   1       2       3     4       5      6      7      8      9      10     11    12     13    14
CAL- = 1.00%, CAL+ = 0.79%
sum of Delta's=  3902, average of Delta's = 278.10
Number of edges found =  15 Distance to 1st edge = 86
```

5.3.4 If the preferred parameters are met, it is not necessary to continue the Scan Linearity adjustment. If you are experienced at this adjustment and wish to set the Sum of Deltas and Distance to first edge to nominal, you may. If the preferred parameters are not met, proceed to 5.3.5.

5.3.5 If the allowable parameters are met, proceed to 5.3.12. If the allowable parameters are not met, proceed to 5.3.6.

5.3.6 If the allowable parameters are not met, the beam may be out of position. To check the position of the beam, press the “p” key. A properly positioned beam will result in the following plot.



```
F Min  F Max  G Min  G Max  Line  File       X
    0   2405      0   2405        line.dat   Y
```

5.3.7 A properly positioned beam will show all 14 bars with a slight gap on either side. Position the beam properly using the following chart. (*Note: The plot window does not update in real time to show beam position changes. To see the results of an adjustment attempt, it is necessary to close the plot window and press the "p" key again.*)

Adjustment	Directions
Make bars wider / Show fewer bars	Turn **R59 Galvo Span** Clockwise
Make bars narrower / Show more bars	Turn **R59 Galvo Span** Counter Clockwise
Move bars to the left	Turn **R58 Galvo Offset** Clockwise
Move bars to the right	Turn **R58 Galvo Offset** Counter Clockwise

5.3.8 If, after the beam has been properly positioned, the allowable parameters are met, proceed to 5.4.12.

5.3.9 Use R59 to adjust the Sum of Deltas to nominal.

5.3.10 Use R58 to adjust the Distance to first edge to nominal.

5.3.11 If the allowable parameters are not met, proceed to 5.4.19.

5.3.12 Use R45 and R47 on the Galvo Driver PCA to adjust CAL+ and CAL- to be as low as possible.

5.3.13 Use R59 to adjust the Sum of Deltas to nominal.

5.3.14 Use R58 to adjust the Distance to first edge to nominal.

5.3.15 Use R45 and R47 on the Galvo Driver PCA to adjust CAL+ and CAL- to be as low as possible.

5.3.16 Use R59 to adjust the Sum of Deltas to nominal.

5.3.17 Use R58 to adjust the Distance to first edge to nominal.

5.3.18 If the preferred parameters are met, the Scan Linearity Adjustment is completed. Press "q" to quit the program. If the allowable parameters are met, it is left to the discretion of the Service Engineer whether or not to try for the preferred parameters. Due to component aging it is sometimes not possible to meet the preferred parameters. If the allowable parameters are not met, proceed to 5.3.19.

5.3.19 It is necessary at this point to perform **Preliminary Scan Adjustment Method A** or **Preliminary Scan Adjustment Method B**. The purpose of this adjustment is to get the Scan Linearity close, so that when the LNADJDT program is attempted again later, the parameters will be closer to nominal.

5.3.20 Preliminary Scan Adjustment Method A

5.3.20.1 Using an ohmmeter, adjust the following potentiometers to the values listed in the chart. For orientation, observe the PCA's so that the PCB writing is from left to right.

Galvo PCA Ohmmeter Connection	Potentiometer	Value
Top pin of TP1 to left side of R25	R98	240 Ohms
Top of R42 to bottom pin of any test point	R47	2.6K Ohms
Top of R40 to bottom pin of any test point	R111	550 Ohms
Left side of R34 to top of R41	R45	26K Ohms
Top of R26 to bottom of R27	R23	500 Ohms

DACQ PCA Ohmmeter Connection	Potentiometer	Value
Right side of R81 to left side of R79	R58	14K Ohms

5.3.20.2 The room lights should be dim and the unit covered to minimize stray light.

5.3.20.3 Place the 14" Linearity Adjust Pattern (P/N 0070-966) in the input slot with the vertical lines facing the unit and the widest red bar towards the abort button.

5.3.20.4 From the "tools" directory, enter LNADJDT /D at the command prompt. Enter the Serial Number of the reader. Press <Enter> to continue. When prompted for Lines to Skip, press <Enter>. When prompted for Black / White Threshold, enter 1200.

5.3.20.5 Use R59 to adjust the Sum of Deltas to nominal.

5.3.20.6 Proceed to 5.3.10.

5.3.21 Preliminary Scan Adjustment Method B

5.3.21.1 Run **DDT**, Option **10**.

5.3.21.2 While observing the laser sweep, adjust **Galvo Span** and **Galvo Offset** so that the ends of the laser sweep extend **1.5 +/- 0.5** inches past the light Collection Chamber opening on the left side and **2.5 +/- 0.5** inches past the light Collection Chamber opening on the right side.

5.3.21.3 Connect oscilloscope trigger sync. channel to **TP8 ("SOS")** on the **DACQ PCA**. Trigger on -Slope and set sweep to 1 ms/div. Connect **channel 1** to **TP7 (Galvo Feedback)** on the **Galvo PCA.**

5.3.21.4 On **CH1** a downward ramp will be displayed. The shorter upward ramp is the retrace. Use **only** **R45** and **R47** make the downward slope to be as straight as possible. This is done by maximizing the peak to peak voltage without allowing **any** right facing curvature of the downward slope. Increasing the peak to peak too much with **R45** will cause right facing curvature near the middle of the downward slope. Increasing the peak to peak too much with **R47** will cause right facing curvature near the top of the downward slope.

5.3.21.5 Visually observe the laser sweep. If the laser sweep extends **1.5 +/- 0.5** inches past the light Collection Chamber opening on the left side and **2.5 +/- 0.5** inches past the light Collection Chamber opening on the right side, then proceed to 5.3.21.6. Otherwise, go back to step 5.3.21.2.

5.3.21.6 The room lights should be dim and the unit covered to minimize stray light.

5.3.21.7 Place the 14" Linearity Adjust Pattern (P/N 0070-966) in the input slot with the vertical lines facing the unit and the widest red bar towards the abort button.

5.3.21.8 From the "tools" directory, enter LNADJDT /D at the command prompt. Enter the Serial Number of the reader. Press <Enter> to continue. When prompted for Lines to Skip, press <Enter>. When prompted for Black / White Threshold, enter 1200.

5.3.21.9 Use R59 to adjust the Sum of Deltas to nominal.

5.3.21.10 Use R58 to adjust the Distance to first edge to nominal.

5.3.21.11 Proceed to 5.3.10.

5.4 PMT Sub System

This section provides the method of adjusting the System for alignment or after replacement of the DACQ PCA, PMT tubes, PMT preamp or Ref Amp.

NOTE

Allow the **LUMISCAN** to warm up for at least 30 minutes prior to making any adjustments.

CAUTION

When making these adjustments, be aware that the Photomultiplier tube is EXTREMELY sensitive to light. When you remove the cover, use a photographic dark cloth to prevent ambient light from damaging the tube or effecting your density adjustments.

5.4.1 PMT Preamp Offset Adjustment

1. Disable the **PMT high voltage**. This is most conveniently done by disconnecting the **AUX I/O** cable on top of the DACQ PCA..

2. Set the DVM for the mV range. Measure at **TP9** on the **DACQ PCA**. If the voltage is **0mV +/- 0.1 mV**, go to **5.4.3**. Otherwise, proceed to step 3.

3. Remove the Front Enclosure from the digitizer.

4. Connect the DVM to **TP1** of the **PMT Preamp PCA**, with the black (-) lead on the pin toward the bottom.

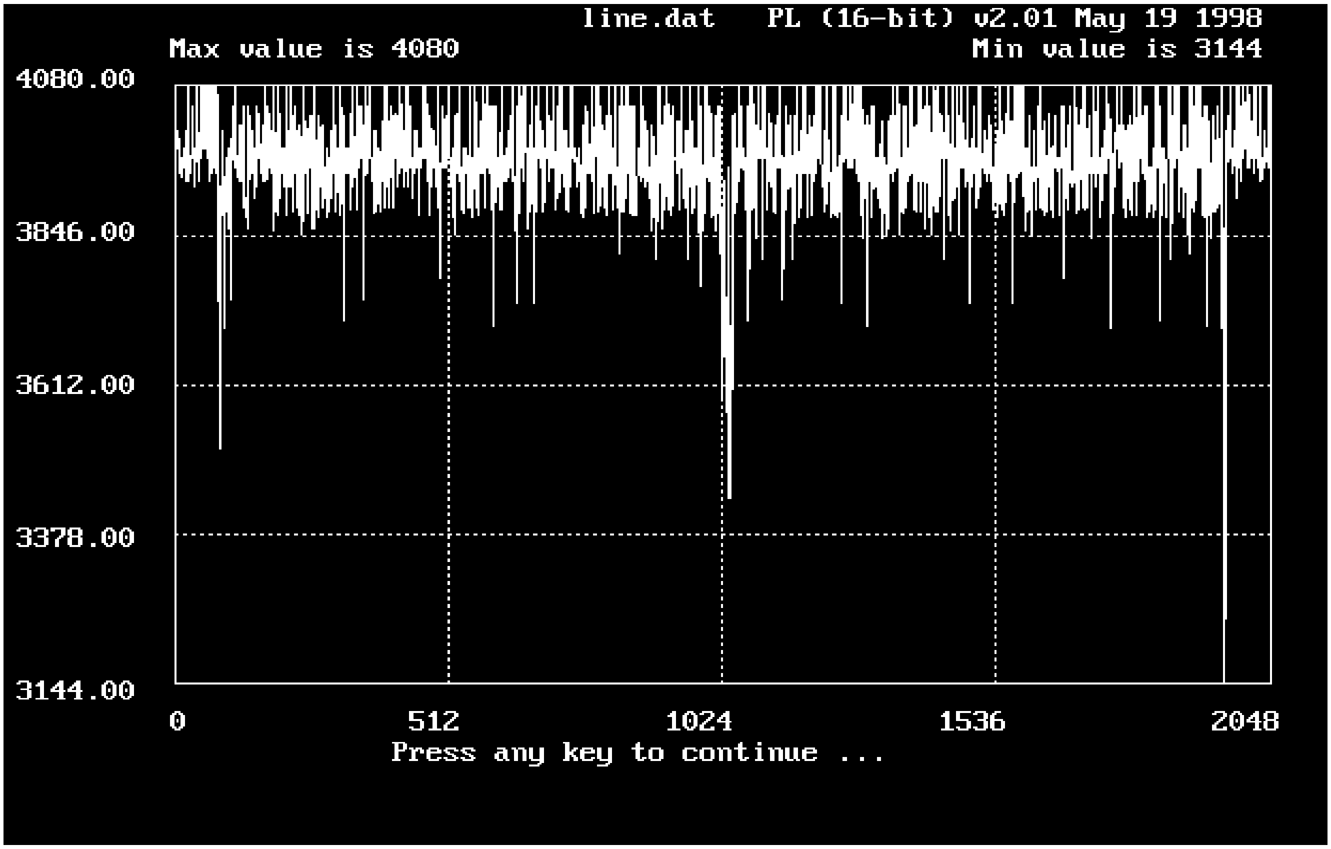
5. Adjust **R8** on the **PMT Preamp PCA** to obtain a voltage of **+0.0 millivolts, ± 0.1 mv.**

6. Replace the Front Enclosure.

7. Disconnect the DVM and re-enable the **PMT High Voltage.**

5.4.2 PMT Output Voltage Preliminary Check

1. Dim the room lights, cover the unit with a dark cloth.
2. Run **DDT/10** and enter a “p”. The display should look as follows:



```
line.dat   PL (16-bit) v2.01 May 19 1998
Max value is 4080                                  Min value is 3144
Press any key to continue ...
```

5.4.3 PMT Output Voltage Adjustment and Reference Blue LED Adjustment

The system must be adjusted so that the signal from a plate exposed at a standard X-ray dosage will give a consistent count level. This depends on the plate used, the laser power, the PMT sensitivity, and the alignment of the DACQ board. This is done by an indirect means: First a plate is exposed to a standard x-ray dose and the PMT high voltage is adjusted so as to give approximately "600" counts during scanning. Thereafter the automatic AGC circuit will act to maintain the overall sensitivity constant, based on the blue reference LED.

Place a well erased 14 x 17" image plate into a cassette. Expose with a dose of 8 mAs at 85 kVp, 71" SID. If a 1mm thick copper plate is available, position the copper plate over the x-ray emitter. This will provide a more uniform exposure. **Verify with a high resolution x-ray dose meter that the dosage is 8 mR +/- 0.05 mR.** Be sure the shutters are opened sufficiently to provide full exposure to the entire image plate. Expose the image plate with nothing on top of it.

1. Be sure that the room is darkened . Cover the unit with a dark cloth to block stray light from entering.
2. Remove the exposed image plate from the cassette and place into the feed slot.
3. Ensure a Cltxxxxx.dat is loaded for the system.
4. Run **DDT/16**. Then run **DDT/20**. Press "**m**" to start the transport motor. When prompted select **980** to set the scanning motor speed. This will transport the image plate at a speed sufficient to produce signal.
5. When the image plate reaches the slot the counts should drop from above 3600 to much lower values.
6. Adjust **R140** on the **DACQ** board so that the reported counts are **600 ±20**.

NOTE

> You will have about 50 seconds to accomplish this. If you cannot finish in this time you must erase the image plate and repeat the procedure. When done and the image plate falls through, erase the image plate.

6. **R140** is now adjusted and should not be changed again.
7. Run **DDT/20**. The counts should be greater than "3600", indicating no signal. Hit " **b**" (to turn the blue LED on) and observe the counts drop.
8. Adjust **R1** on the **Ref Blue LED/Screen Present** board as necessary to get the peak signal counts to reach **1071 ±10**. Once the desired count range is achieved hit the spacebar to exit mode 20

Note

> This now provides a reference signal that is used by the AGC function to maintain PMT sensitivity. Once the adjustment is made the reference LED should require no further adjustment.

5.4.4 PMT Output Voltage Balancing

1. Place a well erased 14 x 17” image plate into a cassette. Expose with a dose of 4 mAs at 85 kVp, 71” SID. If a 1mm thick copper plate is available, position the copper plate over the x-ray emitter. This will provide a more uniform exposure. **Verify with a high resolution x-ray dose meter that the dosage is 4 mR +/- 0.05 mR.** Be sure the shutters are opened sufficiently to provide full exposure to the entire image plate. Expose the image plate with nothing on top of it.

2. Turn the **ACR-2000** Reader off.

3. Remove the front and rear enclosures. Install the cheater keys for Laser power.

4. Remove the top cover of each PMT tower.

5. Minimize ambient light as much as possible and cover the system well with a dark cloth.

6. Apply power to the **ACR-2000 Reader**.

7. Remove the exposed plate from the cassette and place into the feed slot.

8. Connect oscilloscope trigger sync. channel to the top pin of **TP8 (“SOS”)** on the **DACQ PCA**. Trigger on –Slope and set sweep to 1 ms/div. Connect **channel 1** to the top pin of **TP9** on the **DACQ PCA**.

9. Navigate to the “**tools**” directory. Run **DDT**. Select option **16**.

10. Choose option **20**. Observe data scrolling up the screen.

11. Press “**m**” to start the transport motor. When prompted enter **1956** to set the motor speed.

12. Observe the two peaks in the waveform. The left peak is the left PMT as you are facing the Reader. The right peak is the right PMT. Find the PMT with the lowest amplitude.

13. Using the potentiometer on top of the PMT, adjust the lower amplitude PMT to match the amplitude of the other PMT. If the lower gain tube cannot match the amplitude of the higher PMT, both PMT’s must be replaced as a set.

14. Turn the ACR-2000 Reader off.

15. Remove the Laser cheater keys.

16. Replace the PMT tower covers.

17. Replace the front and rear enclosures.

18. It is now necessary to make a new CAL Table. To do this proceed to **5.4.5 Calibration Table Generation**.

5.4.5 Calibration Table Generation

5.4.5.1 Using NT Driver Disk prior to version 2.00.

1. Place a well erased 14 x 17” image plate into a cassette. Expose with a dose of 4 mAs at 85 kVp, 71” SID. If a 1mm thick copper plate is available, position the copper plate over the x-ray emitter. This will provide a more uniform exposure. **Verify with a high resolution x-ray dose meter that the dosage is 4 mR +/- 0.05 mR.** Be sure the shutters are opened sufficiently to provide full exposure to the entire image plate. Expose the image plate with nothing on top of it.

2. While in the "TOOLS" directory, scan a full width plate with a uniform field (exposed plate) using special /NOEDGE and /DS:3 switches.

```
“...TOOLS>SCANFILE  /NOEDGE  /DS:3”
```

This scans at full width scan mode 3 which bypasses the CAL table.

3. While in the "TOOLS" directory, run MKCAL.

```
“...TOOLS>MKCAL LSDT.IMG  CALXXXXX.DAT  -F  2  -N  1000  -Z  160”
```

Copy the CAL table file into the WINNT\SYSTEM32\DRIVERS directory.

Use the LSDT Control panel to select the CAL table filename.

4. Restart the computer.

5.4.5.2 Using NT Driver Disk version 2.00 or later or DOS/95/98 version 3.60 or later.

1. Place a well erased 14 x 17” image plate into a cassette. Expose with a dose of 4 mAs at 85 kVp, 71” SID. If a 1mm thick copper plate is available, position the copper plate over the x-ray emitter. This will provide a more uniform exposure. **Verify with a high resolution x-ray dose meter that the dosage is 4 mR +/- 0.05 mR.** Be sure the shutters are opened sufficiently to provide full exposure to the entire image plate. Expose the image plate with nothing on top of it.

2. From the “tools” directory, run “...TOOLS>MKCALTBL <Serial Number>”. The program will scan the plate and automatically install the new CAL Table.

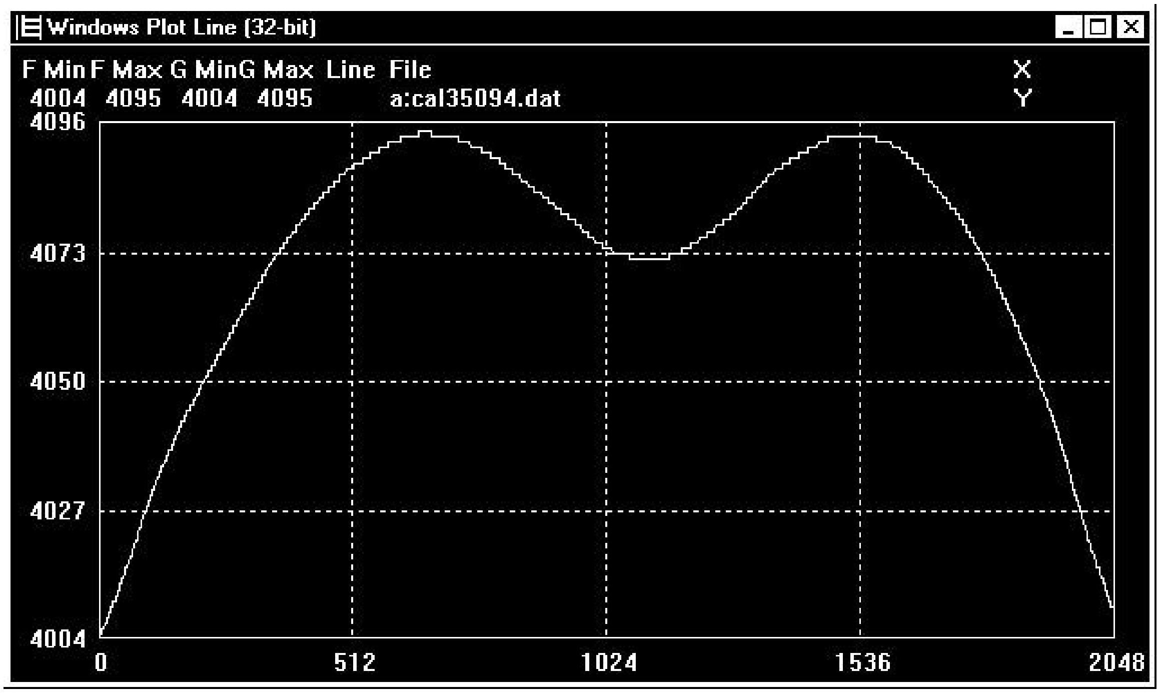
3. Restart the computer.

5.4.5.3 View Plot of the Calibration Table.

1. Go to the command prompt.

2. From the "tools" directory, use the **PL.EXE** command to plot WINNT\SYSTEM32\DRIVERS\CALXXXXX.DAT where XXXXX is the serial number of the ACR Reader. If necessary, hit the "a" key to auto scale the plot.

3. The Calibration Table plot should appear as follows.



```
F Min F Max G MinG Max  Line  File                    X
 4004  4095  4004  4095       a:cal35094.dat          Y
```

Windows Plot Line (32-bit)
4096
4073
4050
4027
4004
0
512
1024
1536
2048

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6.0 PERIODIC MAINTENANCE

System Maintenance is classified in four categories, Daily Maintenance, Routine Maintenance, Periodic Cleaning and Periodic Gain Check. Daily Maintenance and Routine Maintenance are normally performed by the system operator and Periodic Cleaning and Periodic Gain Check are performed by a trained service engineer.

6.1 Daily Maintenance

6.1.1 Clean input guide and output tray with anti-static guard spray daily.

6.1.2 Cover unit at night with lint free cloth or ESD safe plastic sheet.

6.1.3 Clean the storage phosphor screens every day, or every 10 scans.

The physical process by which storage phosphor screens produce CR images does not change over time. The lifetime of the screens, however, is dependent on how they are handled and maintained. Careful handling and proper cleaning of the screens and cassettes will extend their usable lifetime.

Screens should be cleaned after every ten uses. For very high volume facilities, this will mean cleaning the screens at least once, if not twice, a day. Even in low volume facilities, screens must be cleaned once a week. Because they accumulate natural radiation, all screens should be erased once a week.

Clean the screens with a lint-free cloth (for example, KayPees towels). Paper towels, tissue, gauze, or towels should not be used to clean the screens because they leave lint and fibers behind.

Ethyl alcohol, in particular anhydrous denatured ethanol, is recommended for screen cleaning. Apply a generous amount directly to the phosphorous side of the screen and wipe softly and evenly. Also clean the rear side.

Make sure the screen is dry before reloading it into the cassette (allow at least 10 minutes for the solvents to evaporate). It is best to clean the screens at the end of the day so that they will be ready to use the next morning.

Ethyl alcohol and lint-free towels are available from Daigger (www.daigger.com or 800-621-7193). Specially denatured anhydrous ethyl alcohol can be purchased in 500 mL (cat # CX1226A) or 4L (cat # CX1226B) quantities. KayPees disposable paper towels come in cases of 500 (cat #CX5661).

Screens should not be left in the eraser for extended periods of time. Once the screen is erased, it should be removed from the eraser.

6.1.4 Clean area around the system daily. Check for dust.

6.2 Routine Maintenance

Maintenance Periods:

24 times every 12 months.

6.2.1 Cleaning Covers

The outside covers of the **ACR-2000 READER** should be cleaned with a mild soap or detergent. Do not spray cleaner directly on the covers. Spray the soap or detergent on a soft, clean cloth, then wipe down the covers.

6.2.2 Every other week, clean the insides of all the cassettes with a lint-free cloth to remove dust and dirt.

6.3 Periodic Cleaning

Maintenance Periods:

4 times every 12 months.

WARNING

IT IS IMPORTANT THAT THE LUMISCAN COVERS REMAIN ON THE SYSTEM AT ALL TIMES. THE COVERS SHOULD ONLY BE REMOVED FOR SERVICE, AND THEN IMMEDIATELY REPLACED. THIS WILL MINIMIZE DUST ENTRY.

WARNING

THIS EQUIPMENT EMPLOYS A LASER. LASER RADIATION MAY BE PRESENT IF THE LUMISCAN ACR-2000 READER IS OPERATED WITHOUT COVERS.
AVOID LASER BEAM. DIRECT EYE EXPOSURE TO LASER LIGHT MUST BE AVOIDED

CAUTION

BE SURE TO USE PROPER ESD PRACTICE WHEN TOUCHING THE ACR-2000 READER WITH THE COVERS OFF

CAUTION

DO NOT CLEAN THE GALVO MIRROR OR ROOF MIRROR EXCEPT AS A LAST RESORT AND UNDER THE GUIDANCE OF LUMISYS TECHNICAL SUPPORT

NOTE

DUST OR FIBERS IN THE LASER BEAM PATH MAY AFFECT THE RADIOGRAPHIC IMAGE

6.3.1 The main objective is to remove particles that may cause vertical lines in images.
6.3.2 Digitize an image for comparison with performance after cleaning.
6.3.3 Remove the ACR-2000 READER main cover.
6.3.4 Remove the fan filter and clean with warm soapy water.
6.3.5 Remove the front cover.
6.3.6 Vacuum the interior.
6.3.7 Manually turn the rollers and clean the rollers with a damp lint free cloth.
6.3.8 Clean the laser entry slot of the light collection chamber with lens tissue and a compressed gas duster.
6.3.9 Remove the front pressure plate.
6.3.10 Remove any lint that may be adhering to the laser output slot. Use lens tissue and a compressed gas duster.
6.3.11 Replace front pressure plate and covers.
6.3.12 Digitize an image and check for vertical lines. If lines remain, look for lint and particles corresponding to the position of the remaining lines. A flashlight can be used to illuminate lint particles.

6.4 PMT Output Voltage Adjustment and Reference Blue LED Adjustment

1. Perform the **PMT Output Voltage Adjustment and Reference Blue LED Adjustment** as specified in **Chapter 5** section **5.4.3**.

7.0 DIAGNISTICS

If a system failure occurs, it is necessary to diagnose the cause before effecting the repair.

This section describes the diagnostic tools and techniques used to isolate various types of system failures.

7.1 Troubleshooting

The cause of some failures may be obvious. In these cases, the Service Engineer may proceed directly to the repair.

Before beginning an investigation, it is a good practice to record as much information about the current state of the system as possible. This information may include, but is not limited to, symptoms, conditions under which symptoms exist, voltages, settings, cleanliness, and visual state.

Normal generic troubleshooting techniques apply. With knowledge of the system, isolate the failure to a particular subsystem. With knowledge of the subsystem, trace the symptom back to its cause.

In many cases, failures are caused by lack of periodic maintenance and cleaning. If a system is known to be behind schedule for its maintenance and cleaning at the time of the failure, it is a good practice to clean and recalibrate the system before extensive troubleshooting. In many cases this solves the problem or provides clues as to the cause.

7.2 Symptoms and Their Causes

Here are some of the most common symptoms of system failures and some known causes.

7.2.1 Vertical Lines In Images

If the lines are random within an image but repeatable in each successive image, there is likely lint blocking the beam near the focal point of the **Laser**. This is the most common cause of vertical lines. The procedure for removing lint is in **Chapter 6**.

If cleaning doesn’t remove the lines, moving the beam up or down a couple of millimeters sometimes helps. This is done with the 45 degree roof mirror

7.2.2 Horizontal Lines and Banding In Images

The most common cause of horizontal lines is excessive ambient light. Verify that the light present in the room is 2EV maximum.

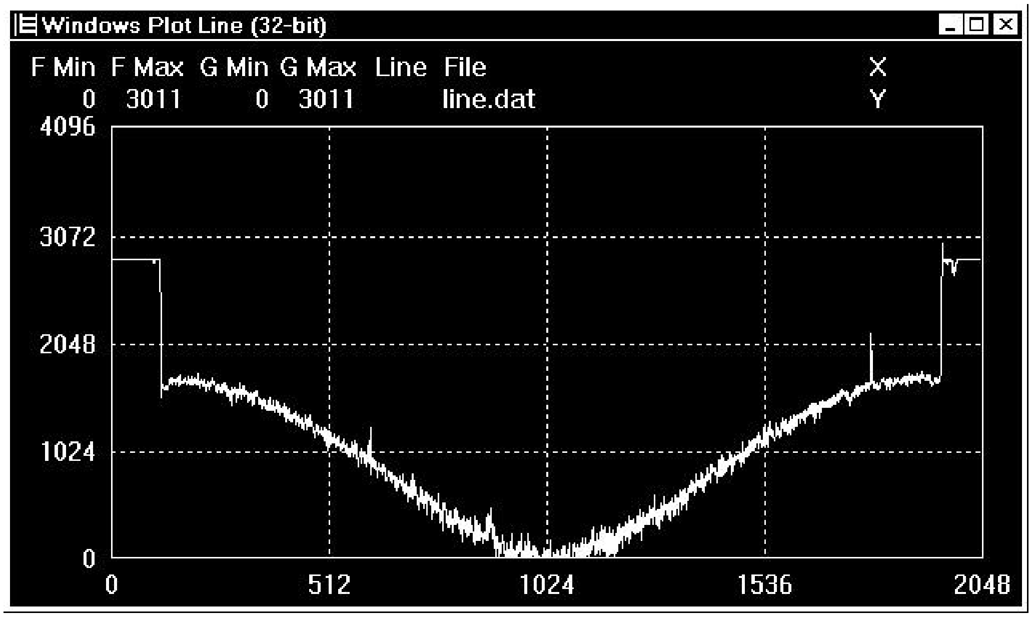
In many cases, too much ambient light will create dark horizontal bands at the top and the bottom of images.

7.2.3 System Will Not Detect Phosphor Screens

If the screen moves into the system several inches and stops without backing up, the screen is not being detected. The most common cause of this failure is a failed **Laser Module**.

To determine if the Laser is functioning, remove the main enclosure, turn the Laser on and visually determine if the Laser is functioning. Ensure that the interior of the scanner is not exposed to ambient light, as this might damage the **Photo-Multiplier Tubes**. Also, enable the Laser interlock with one of the interlock keys clamped to the side of the frame. To activate the Laser, run the **DDT.EXE** program, which is located in the Lumisys “tools” directory. Then, select option **20**, which turns the Laser on and makes it scan back and forth across the light collection chamber. If the Laser is not emitting light, the Laser Module needs to be replaced. If the Laser is emitting light, it is possible that it is not emitting enough light.

To check for adequate Laser light, manually push an erased phosphor screen six inches into the rollers. This will ensure that the screen is in the Laser path. Then run the DDT.EXE program from the “tools” directory. Select option 20. Press the “i” key to activate the screen detector. Press the “p” key to plot the detection signal. On most ACR Readers, the screen detector signal will appear as follows.



F Min	F Max	G Min	G Max	Line	File	X
0	3011	0	3011		line.dat	Y

This is an inverted signal with the highest amplitude at the bottom of the plot, which is a value of zero. If the amplitude is not near zero, as an example 500 or 1000, the Laser is not emitting enough light and needs to be replaced.

The screen detector plot for older ACR Readers is three spikes, each with an amplitude of approximately **1600**. ACR Readers with **Data Acquisition PCA** part numbers **0070-735** and below have this older screen detector. If the spike amplitude is significantly below 1600, as an example 500 or 1000, the Laser is not emitting enough light and needs to be replaced.

If there are less than three spikes visible, the Laser may not be aligned with the screen detectors. The procedure to realign the old style screen detectors is in the **Chapter 5** paragraph titled, **Plate Detector Alignment**.

7.2.4 Non Uniformity of Density

Non uniformity of density is where one side of the image is significantly darker or lighter than the other side. The primary cause for this is a failed PMT. To determine which one of the two PMTs has failed, attempt scans with each PMT disconnected from its cable. The PMT that, while disconnected, has no effect on scanned images is the PMT that needs to be replaced. When replacing a PMT, be sure to perform the **PMT Output Voltage Balancing Procedure** and the **Calibration Table Generation Procedure**. Both of these procedures are in **Chapter 5**.

7.2.5 DI-2000 Self Test Failure

If **Autozero** and **AGC** both fail, the PMTs are suspect.

If **Autozero** fails, there may be too much ambient light in the room.

If **AGC** fails, perform the **PMT Output Voltage Adjustment and Reference Blue LED Adjustment** which is in **Chapter 5.**

7.2.6 No Photo-Multiplier Tube Output

Verify that the Laser is emitting light, by using DDT.EXE option 20, with the Laser interlock installed. If the Laser is not emitting light, the Laser Module needs to be replaced.

Attempt to perform the **PMT Output Voltage Adjustment** which is in **Chapter 5**. The initial measurement of the PMT Output Voltage mean data value before the adjustment should normally be between 600 and 1000. If the mean data value is near 4095, the PMTs are probably not getting voltage from the **PMT High Voltage Power Supply**.

CAUTION

THE PMT HIGH VOLTAGE IS SEVERAL HUNDRED VOLTS DIRECT CURRENT

Using a Digital Volt Meter set to DC Volts, check the PMT High Voltage by measuring the voltage from the top pin of **Test Point 2** (voltage) to the bottom pin of **Test Point 1** (reference) on the **PMT Preamp PCA** which is located behind the front cover. The voltage should be above –300VDC. If the voltage is near zero, the **PMT High Voltage Power Supply** is likely to have failed.

If there is voltage at Test Point 2, check the cable between the PMT Preamp PCA and the Data Acquisition PCA for bent pins.

7.2.7 No Galvanometer Movement

The most common cause of no Galvanometer movement is failed drive circuitry on the Data Acquisition PCA.

Remove the AUX/IO connector from the Data Acquisition PCA to disable the PMT High Voltage Power Supply. This will protect the PMTs from ambient light during the investigation.

Manually roll a 14X17 inch plate into to the beam slot to serve as a backdrop for the laser light.

Run DDT.EXE option 20 to activate the Galvanometer. Install the Laser interlock key.

If the beam is sweeping back and forth across the plate, the Galvanometer is functioning properly.

Disconnect the Galvanometer drive signal cable at the Data Acquisition PCA connector labeled “GALVO”. Disconnect the other end of the same cable from the **Galvo Driver PCA**. Use an oscilloscope to monitor the Galvo drive signal at the top pin of **Test Point 6** on the DACQ PCA. If there isn’t a drive signal present, the DACQ PCA is malfunctioning or is adjusted to zero Galvo span.

If there is a drive signal present, connect the drive signal cable to the DACQ PCA while leaving the other end disconnected. If the drive signal is lost, the cable needs to be replaced.

If the drive signal is still present, connect the drive signal cable to the Galvo Driver PCA. If the drive signal is lost, the Galvo Driver PCA needs to be replaced.

If the drive signal is still present, verify with a DVM that the Galvo Driver PCA is receiving its input voltage of +15VDC and –15VDC. This can be measured at **L1** and **L2** on the Galvo Driver PCA.

If the Galvo Driver PCA is receiving its proper input voltage, attach the oscilloscope to the junction of R66 and R67 on the Galvo Driver PCA. If there is a drive signal, detach and reattach the Galvanometer. If the Galvanometer still doesn’t function, it needs to be replaced. If there is no drive signal to the Galvanometer, the Galvo Driver PCA needs to be replaced.

7.3 Diagnostic Programs

This document outlines use of some of the diagnostic programs. The Diagnostics programs are used **exclusively** for diagnostics, testing, aligning and troubleshooting of the **ACR-2000 READER**. They are intended to be used by service engineers for diagnostic and test purposes only.

The following is a list of the current diagnostics that support the **ACR-2000 READER** product.

Here is a list of some of those diagnostics

C:\LSDT32\TOOLS- LSDT tools, programs

LNADJDT.EXE - Linearity adjustment
DDT.EXE - Diagnostic used to exercise the Driver & Scanner
PL.EXE - Plots a line of data or a file to display
SCANFILE.EXE - Example image acquisition application

7.3.1 DDT.EXE

Enter > DDT
Enter one of the specified numbers (1 through 22, or 'q') at the command prompt.

```
                         DDT  VX.X      <date>    <time>

1.  Scan File                        11. Change Parameters
2.  Read Data                        12. Start Motor
3.  Read Status                      13. Diagnostic Scan
4.  Load LUT                         14. Test Image Memory
5.  Read LUT                         15. Stop Scan & Eject
6.  Clear CAL Table                  16. Reset Hardware
7.  Plot CAL Table                   17. Set Averaging Mode
8.  Reset Scan                       18. Set Laser Mode
9.  Test CAL/LUT                     19. Pulse Screen Feed
10. Display A/D                      20. Display Noise Value
21. System Info                      22. Set CR/Scan5 Modes
      q. Exit Program
          command ->__
```

Enter > **1** (Scan Screen) - insert screen to be scanned. Screen will be scanned, image will be stored in DCB memory.

You can also test the SCAN ABORT button when scanning a screen. Press the SCAN ABORT button any time during a scan. Pressing SCAN ABORT has the following effect: Press SCAN ABORT (1st time) - stops screen
Press SCAN ABORT (2nd time) - reverses screen
Press SCAN ABORT (3rd time) - stops screen
Press SCAN ABORT (4th time) - forwards screen
Press SCAN ABORT (5th time) - stops screen

Enter > **2 Read Screen** - this reads the image stored in DCB memory (by a previous SCAN SCREEN) into a file. The default file is LSDT.IMG.

Enter > **3 Read Status** - the current status of the scanner driver is displayed

Enter > **4** (Load LUT) - download to the DACQ a specific LUT.

Enter > **5** (Read LUT) - read from the DACQ a specified LUT. The LUT you read should reflect the LUT you most recently downloaded to the DACQ.

Enter > **6** (Clear CAL table) - clears the CAL table on the DACQ to 4095.

Enter > **7** (Plot CAL table) - plots the DACQ CAL table. A normal CAL table will look somewhat like an irregular "M" shape. A screen must be scanned before a Cal curve is generated.
Enter > **8** (Reset Scan) - This resets the scanner driver.

Enter > **9** (Test CAL & LUT Memory) - This writes a specified pattern to the LUT

Enter > **10** (Display A/D Value) - This writes a specified pattern to the LUT memory. Resources are either FAILED or PASSED. See 7-10.

L = Laser on/off 1=dim 2=full on 0=off
E =
B = Turn the Blue on and off
V =
I =

Enter > **11** (Change Parameters) - You can change any of the following DACQ timers. Numbers given are example calculated values.

1. Scan Motor Clock = 25000
2. Screen Motor Clock = 1956
3. Pixel Clock = 122
4. Delay to First Pixel = 1484
5. Pixels Per Line = 2048
6. Lines Per Screen = 5
7. Variable Scan Mode = VARIABLE
8. Bits Per Pixel = 12 Bits
9. Pixel Byte Order = LSB/MSB
10. Reset to Defaults

Select Parameters ->

Enter > **12** (Start Motor) - You can start the motor in the specified direction.

Enter > **13** (Diagnostic Scan) - perform a specified diagnostic scan from the sub-menu.

Enter > **14** (Test Image Memory) - the specified pattern is echoed to the DCB memory. PASSED or FAILED are the expected responses.

Enter > **15** (Stop Scan & Eject) - Stops the scan in progress and ejects the screen.

Enter > **16** (Reset HARDWARE) - This resets the scanner driver(doesn't reload the driver), the DACQ & DCB hardware. Also reloads the CLUT.

Enter > **17** (quit) Set Averaging Mode) - Unused for current system.

Enter > **18** (Set laser Mode) - Turns LEDs on and off.

Enter > **19** (Pulse Screen Feed) - Loads a screen from the screen loader.

Enter > **20** (Display Noise Value)-
M =
B =

Enter > **21** (System Infor)- Detailed system information

Enter > **22** (Set CR/Scan5 Mode) -
Other commands you may enter (not specified by the **DDT menu**);

Enter> **o** (oscope)- plots the scanline to the screen.
Enter > **s** (screen) - dump contents of screen to a file
Enter > **pl** (plotcal) - Plots a data file to the screen, ie: results.dat.

The following sections are guidelines for troubleshooting sections of the scanner using **DDT**.

Autozero Check

The room lights should be dim and the unit covered to minimize stray light. Run **DDT** option **13/5**. Observe the reported results and verify that the voltage reported for Autozero is within the limits ±1 volts(the closer to 0 the better). If not check the offset adjustment of the PMT Preamp, which should be 0 mv with P14 disconnected from the DACQ.

Verify AGC Function

Run **DDT** option **13/5** and verify that the reported AGC voltage is within ± 1.0 volts, indicating little or no AGC compensation required. Unplug the blue LED cable from J1 of the Ref LED/Scrn Pres board and rerun option 13/5. Verify that the AGC voltage is more positive, indicating that it is adding high voltage to compensate for signal loss. Reconnect the blue LED to J1 and repeat 13/5. Verify that the voltage decreases.

Test DACQ Calibration and Lookup Table Access

Run **DDT.** From the menu choose **9. Test CAL and LUT Memory.** From the submenu choose 1. Up Ramp Test. The test was successful if the screen prints "PASSED" and returns to the main menu, otherwise it will print the first 64 errors. Repeat test 9 for the following submenu choices:

2. Down Ramp Test
3. Walking 1 Test
4. Walking 0 Test

Test Cal Table Clear Function

From the **DDT** menu choose **6. Clear Calibration Table.** There will be no output - the screen just redisplays the menu. Choose **7. Plot Cal Table.** A graph should appear on the screen displaying 1024 values of 4096 (Max Value = 4096, Min value = 4094). Press any key to return to menu.

Test Lookup Table Load and Readback Function

From the DDT menu choose **4. Load LUT.** A list of choices will be displayed. Select 1 = 0:4095 12 Bit Lut. Select 15. Choose **5: Read LUT**. Select 15 . All 4096 values (in hex) will scroll up the screen in lines of 16. Observe the last column as it scrolls: Verify that the last digit is always "F" while the first digit of the last column increments from "0" through "F". The last few lines will remain on the screen. Verify that the last line is:

```
FF0 FF1 FF2 FF3 FF4 FF5 FF6 FF7 FF8 FF9 FFA FFB FFC FFD FFE FFF
```

followed by a return to the menu.

Test Digital-only Data Path

From the DDT menu choose **11. Change Parameters** and then **6. Lines Per Image** and enter 1024. Return the the main menu and select **13. Diagnostic Scan**. From the submenu choose **7- Diagnostic Pattern.** In response to the query "Do overlapped writes to a LSDT.IMG [default=y]", just press Enter. Wait for the return to the main menu. This causes the DACQ under test to generate a test pattern consisting of 256 lines of data values 0 through 1023, followed by 256 lines of data values 1024 through 2047, and so on.

From the DDT menu enter the following command line: **H12,** the following line will appear:

```
hist12 0 lsdt.img 1024 1024 0 2048 | more
```

This executes the program HIST12, which counts the number of occurrences of each data value in the range 0 through 4095, any displays the results on the screen which you can pause by hitting <ctrl>S, then any key to resume. Examine each screenful and verify that every reported count is 256. Hit any key (such as the spacebar) to display the next screenful; repeat for the entire file and until the DDT menu returns.

Verify that the last line displays the following message:

"Total Occurrences = 1048576". (which is 1024 pixel X 1024 lines).

When complete the screen returns to the main menu.

Repeat this entire test, except in the submenu choose **6- Flat Field Pattern.** When the results of HIST12 are displayed, verify that the reported count for every value is 0 except for 1285, which should have a count of 1048576.

Choose **11: Change Parameters**. Select **9- LSB/MSB.** This will reverse the order to MSB first. Hit <enter> to return to main menu. Repeat the diagnostic scan with mode **7- Diagnostic Pattern** Repeat the HIST12 analysis. This time, since the byte ordering has been reversed the results reported by HIST12 should be as follows: As the numbers scroll past you should see 16 groups of 16 consecutive bins with 4096 counts each, and all other bins with 0 counts. The groups will be located at bins 0 through 15, 256 through 271, 512 through 527, and ending with 3840 through 3855.

7.3.2 SCANFILE

Scanfile using the following parameters:
Pixels per line : 2048
Pixel depth : 12 bits/pixel
Pixel format : LSB
LUT format : Normal
Filename : lsdt.img

The command line for "SCANFILE" has the following format:

```
SCANFILE  /PPL: /PD: /PF: /LUT: /F: /TIF /AM /PMT /PPI /NOEDGE /EDGE
```

Options available are:

PIXELS PER LINE: Default is 1024
/PPL:x Set PIXELS PER LINE to x

PIXELS PER INCH
/PPI: pixels per inch

PIXEL DEPTH: Default is 12 bits
/PD:12 Set PIXEL DEPTH to 12 bits/pixel
/PD:8 Set PIXEL DEPTH to 8 bits/pixel

PIXEL FORMAT: Default is LSB first
/PF:LSB Set PIXEL FORMAT to LSB first
/PF:MSB Set PIXEL FORMAT to MSB first

LOOK UP TABLE: Default is Normal
/LUT:N Set LUT to normal - 0.0 Optical Density = 0
/LUT:I Set LUT to inverted - 0.0 Optical Density = 4095

OUTPUT FILE: Default is lsdt.img
/F:filename Set filename

Tiff File Format:
/TIF Set to create TIFF image file

Averaging Method
/AM: X or XY

PMT Register

/PMT: 0 through 255

Edges

/NOEDGE
/EDGE

If the user would like to scan a screen into a file called image5.img using defaults, from the MS-DOS prompt type:

"scanfile /f:image5.img"

This command will digitize a screen using 12 bits, 1024 pixels in width, create a header and put a file named image5.img in the current directory.

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8.0 INTRODUCTION

This section discusses the various components of the **LUMISCAN ACR-2000 READER** digitizer that can be replaced in the field. It also details the removal of the **LUMISCAN ACR-2000 READER** covers, along with component removal and replacement. Components which can be replaced in the field are called field replaceable units, or **FRUs**. These will be discussed later in this section.

8.1 Removing the LUMISCAN ACR-2000 READER Covers

This section reviews the removal of the **LUMISCAN ACR-2000 READER** outer panels. There are two individual panels on the **LUMISCAN ACR-2000 READER**, and for the purposes of this manual they are labeled Front cover and Main enclosure.

8.1.1 **Main Enclosure Removal**

The Main enclosure is the rear cover of the system. To remove the Main enclosure perform the following:

1. Remove the system interface cable and the A/C power cable.
2. Remove the 3 phillips screws from the rear of the system.
3. Remove the 3 phillips screws from each side of the system. Total of 6.
4. Remove the main enclosure by sliding it to the rear of the system and off.

8.1.2 **Front Cover Removal**

1. Remove the 4 phillips screws (2 on each side) from the front cover.
2. Remove the three screws attaching the front of the enclosure to the interior alignment bar.
3. Disconnect the two cables coming from the front going to the DACQ PCA.
4. Remove the front cover.

8.2 Field Replaceable Units (FRUs)

Overview

This section discusses the sub-systems and components in the **ACR-2000 READER** that can be replaced in the field. These are called **Field Replaceable Units** or **FRUs**. Certain **FRUs** may require some adjustments when they are replaced. The following chart details all of the FRUs in the **READER** that have adjustment requirements when they are replaced. All adjustments are contained in **Section 5** of the Service Manual.

Sub-Assembly	FRU	ADJUSTMENT
Optics	PMT PreAmp PCA	PMT
	PMT Tubes	PMT
	Laser	Optical, PMT
	Galvo PCA	Linearity
	Galvo Motor	Linearity
Electronics	DACQ PCA	PMT, Linearity
Pinch Rollers	DC Drive Motor	-None
Power Supply	15VDC Supply	15VDC Supply
	-1Kv PMT Supply	PMT

8.3 Optics Module

Inside the system, there are 5 components that can be replaced in the field. These are:

1. PMT Tubes
2. PMT PreAmp PCA
3. Laser
4. Galvo PCA
5. Galvo Motor

8.3.1 PMT SUB-SYSTEM

The PMT sub-system (the PMT Tubes and PMT PreAmpPCA) can be replaced by following the procedure outline below

PMT PRE-AMP PCA REMOVAL

The following tools will be necessary to remove the PMT system:

1. Flat blade screwdriver
2. Philips #2 screwdriver

The PMT PreAmp PCA is located at thetop of the Collection Cylinder (Figure 8-2). Remove the Main enclosure and Front cover to gain access to the PMT Preamp.

CAUTION: There are several wires coming from the tube's connector going to J6 on the PMT PCA. These wires are fragile and could break if mishandled.

1. Unplug J14 on the DACQ.
2. Remove the PMT PreAmp assembly cover by removing the 2 pan head screws.
3. Remove the 3 cables going to the PMT Pre-amp.
4. Remove the 4 mounting screws from the PMT PreAmp PCA and remove the PCA.
5. Replace and secure PCA, reconnect cables and replace PCA cover.

PMT REMOVAL AND REPLACEMENT

When replacing a failed PMT it is required procedure to replace both tubes with a matched pair. The gain characteristics of unmatched tubes can be such that they cannot be balanced.

Newer models may have a different configuration than described below where there is a single PMT tower containing both tubes. In this case there will be foam "doughnuts" providing pressure and holding the tubes in place. In this case simply removing the top cover and foam doughnuts from the PMT tower will allow you to remove the tubes. Replacement is self-evident. Also note that in this newer configuration the blue filters are not held to the tubes by photographic tape.

Ensure that power to the machine is off.

1. Remove the covers and the cable from the PMT sockets. Remove the PMT connection cable from the tubes and the preamp.
2. Remove the four 9/64" screws securing each PMT Tower. Lift the towers off the collection cylinder.

3. Loosen the two 7/64” clamp screws recessed in the back side of the tower. Remove the PMT face first (from the bottom), being careful not to get fingerprints on the blue filter.

4. Remove the blue filter attached to the PMT.

5. Attach the blue filter to the replacement PMT with black photographic tape. Overlap the top of the filter with about 1/8 inch of tape. Fold the tape edge over the filter to secure the filter to the PMT. It’s important to get the tape as flat as possible on the filter to avoid light leaks which will cause vertical artifacts in an image.

6. Insert the PMT into the tower and place the tower face down on a clean surface such as a table top with a soft cloth. By setting the assembly on a table it is a simple matter to get the tube flush with the bottom of the tower.

7. Note that the tubes are keyed where they connect with the cable. Position the tubes so that they fit the cable’s sockets. Facing the machine from the front, the left tube should be keyed toward “12:00” while the right tube key is at “3:00”. Gently and evenly tighten the PMT clamps with the two clamp screws. Do not over tighten or damage to the tube may occur.

8. Perform the PMT Offset Voltage adjust, PMT balancing, High Voltage adjust and blue LED adjust (Refer to section 5.4 of this manual).

8.3.2 LASER DIODE MODULE

LASER DIODE DRIVER ASSEMBLY REMOVAL AND REPLACEMENT

WARNING

USE PROPER ESD PRACTICE WHEN TOUCHING LASER OR SCANNER

EXTREME CAUTION

1. The laser assembly produces 18 to 25 mW of power. Care must be taken to avoid looking directly at the beam.

2. The Laser Diode output is transmitted to the lens through a fiber optic cable. The end of this cable has a protective cap that is removed when the cable is screwed into the lens assembly. Great care must be taken so that the end of the cable does not come into contact with anything, i.e., fingers, metal, etc., or damage will occur.

3. Special attention must be given to adding jumpers on JP2 and JP3 on the Laser Diode Driver board when removing the laser assembly, and removing these jumpers after the replacement assembly is installed. If these steps are not followed carefully, damage can occur to the laser diode.

REMOVING LASER DIODE MODULE

1. Turn off the system and remove the main enclosure.

2. Remove the Galvo PCA/bracket assembly from the bulkhead leaving the galvo motor connected. Set the PCA/bracket assembly inside the reader away from the laser assembly.

2a. The bracket is secured to the bulkhead by two phillips head screws and an 5/16" hex head nut.

3. Install jumpers across JP2 and JP3 on the Laser Diode Driver PCA. Those jumpers are shipped from the factory hanging off one of the pins of each jumper.

4. Disconnect the interlock cable from the interlock switch.

5. Disconnect the DC power cable going to J1 on the Laser Diode Driver PCA.

6. Observe the ferrule securing the tip of the fiber optic cable to the F/C mount in the lens barrel. With your fingers, gently unscrew the ferrule then very gently slide the cable the lens assembly. Be extremely careful not to contaminate or damage the tip of the cable. Immediately place the protective cap over the end.

7. Remove the four 7/64" hex screws securing the Laser Diode Driver Assembly to the bulkhead.

8. Remove the Assembly and place in the protective anti-static package the replacement arrived in. Return the assembly to Lumisys.

REPLACING LASER DIODE MODULE

1. Mount the Laser Diode Assembly to the bulkhead using the four screws.

2. Remove the protective cap from the end of the fiber optic cable. Be extremely careful to not touch the exposed end of the cable with anything or damage will occur. Note the key at the cable end and place properly to the lens assembly. Secure by turning the locking ferrule finger-tight.

3. Connect the power cable to J1 of the Laser Diode Driver PCA and remove the protective jumpers from JP2 and JP3. Place the jumpers on one pin of JP2 and JP3 in case the assembly has to be removed in the future.

4. Connect the interlock cable to the interlock switch.

5. Reinstall the Galvo PCA.

Refer to Section 5 “Final High Voltage Adjustment and Reference LED Adjustment” to set the high voltage and Blue LED.

Occasionally after replacing the laser module the spot size is adversely affected resulting in poor image resolution. The fiber optic tip not being inserted correctly into the connector on the lens barrel assembly often causes this. If there is a resolution problem it is always best to confirm that the connection between the fiber optic cable tip is keyed correctly. If you are confident that the fiber optic tip is placed correctly in the connector and resolution is still poor then it may be necessary to re-focus the beam.

FOCUSING THE LASER

Focusing the laser beam is **never** done as part of a standard PM. The beam spot is set at the factory and will not change without a preceding event such as changing the laser itself. Gain, laser power and cleanliness could all effect resolution quality. **Never** re-focus the laser without consulting a member of the Lumisys Technical Support Staff.

An oscilloscope, a very dim light environment, a non shedding cloth (preferably an opaque photographic shroud) to drape over the machine and a red Lumisys QA pattern are required for this procedure.

1. Remove the main enclosure, place a cheater key in the interlock, dim the lights and cover the reader with the opaque cloth.

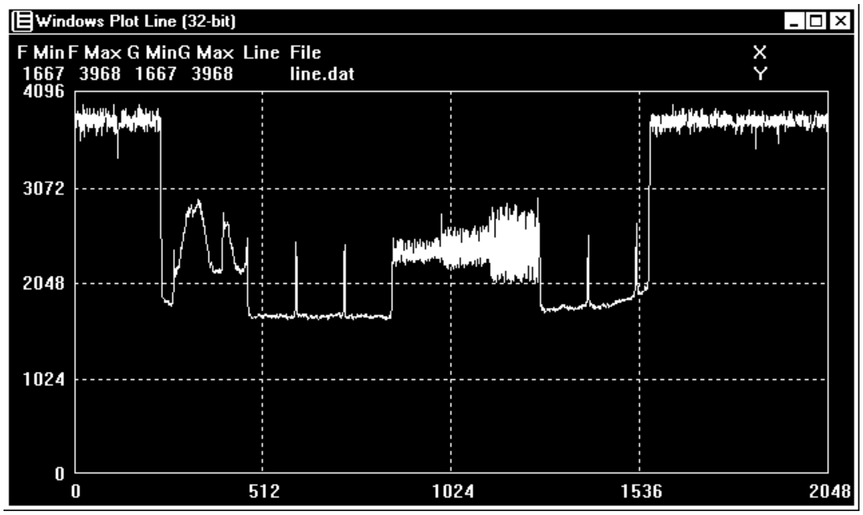
2. Connect channel one of the scope to SIG (TP1) and sync off SOS (TP8).

3. From the tools directory Run ddt option 20.

4. On the lens barrel assembly the two set screws that are nearest the fiber cable end of the assembly secure the F/C connector in the barrel assembly preventing it from moving.

5. Loosen these two set screws with a 1/16” hex-head wrench such that they are still putting a small pressure on the F/C connector. This pressure will help with control during the minute changes you will be making during the focusing procedure. Furthermore if the set screws are too loose focus will probably be effected when you retighten them.

6. Place the red Lumisys QA test pattern in the reader such that a block set of three line pair patterns are in the beam path. Notice that there are three distinct, side by side traces representing the three different line pair densities with three different amplitudes. The tightest line pair pattern will have the smallest amplitude.



Triple block line pair pattern trace (at center).

7. While gripping the locking ferrule (which you tightened when you put the fiber optic cable tip) gently move the connector until you see amplitude changes in the line pair traces. You want to achieve the best possible amplitude of the smallest line pair block. The actual amplitudes will vary some from test pattern to test pattern. The vertical setting on the scope should be as sensitive as possible.

8. Once you are confident that you have the best possible amplitude tighten the two set screws firmly but not too tight. Make sure the ferrule is still tight on the connector.

9. Scan the red Lumisys QA Test Pattern and view the image. The lines of tightest line pair pattern should be distinct, though some aliasing will be evident.

8.3.3 GALVANOMETER REMOVAL

Turn power off

1. Remove the Main cover.

2. Remove the Galvo access cover.

   2a. The Galvo Access Panel is on the rear bulkhead secured by six 5/16” nuts

3. Remove the Galvo driver board/bracket assembly from bulkhead.

   3a. The bracket is secured to the bulkhead by two phillips head screws with washers and one 5/16” hex head nut.

   3b. Clip tie-wrap securing the Galvo Motor cable to bracket

4. Unplug the Galvo Motor cable from the driver board.

5. Remove the four 7/64” hex-head screws holding the Galvo motor from the Galvo mount assembly. Be very careful not to scratch the replicating mirror.

6. Remove the Galvo motor and retain the 4 plastic shoulder washers and plastic isolation gasket.

7. Remove the replicating mirror from the galvanometer shaft.

7a. The mirror is secured by a .050” nylon tipped set screw. It is not necessary to remove this set screw entirely. Just loosen it enough to easily remove the mirror. Leave the set screw in place.

7b. Be very careful to not touch the mirrored surface when removing the mirror from the galvanometer shaft. It is best to use a soft lens cleaning paper or cloth and grip the sides of the mirror with your fingers and slowly slide the mirror off the galvanometer shaft.

REPLACEMENT

Re-install the new Galvo motor in the reverse order except do not re-place the mirror until the other components are in place. Re-installing the tie-wrap and isolation gasket are important steps. That galvo cable, if not tied up, could obstruct the laser exiting the galvo tower.

Replacing the Replicating Mirror and Locating Mechanical Center.

1. After the Galvanometer is securely mounted on the galvo tower slide the replicating mirror back onto the galvanometer shaft.

2. Place a Post-It note or similar object, centered, over the entrance slot of the collection chamber.

3. With a pen or pencil mark the Post-It with a dot on the horizontal center of the collection chamber. This can be done by eye using landmarks such as the PMT towers. Bisect the area between the PMT towers to find the center of the collection chamber. Do not use the tape on either side of the collection chamber as a reference.

4. Ensure that J14 on the DACQ and J3 on the Galvo PCA are unplugged. This will disallow high voltage to the tubes and power to the galvo respectively. Ensure that the interlocks are actuated.

5. Turn on power.

6. Without touching the mirrored surface, using the mark on the Post-it note as a reference, carefully rotate the replicating mirror until the beam spot is centered with respect to the collection chamber. Don’t worry if the spot is not perfectly aligned along the y-axis (vertically bisecting the slot itself) and slightly above or below the mark.

7. Tighten the set screw on the mirror.

8. Replace the access cover. Ensure that all relevant fasteners are secure and connectors plugged in.

Realign the Galvo motor per **Section 5.3** of this manual.

8.4 DRIVE MOTOR/ENCODER ASSEMBLY

Removal

Notice and remember the orientation of the encoder at the end of the drive motor.

Cut the tie-wraps securing the encoder cable and motor cables.

Disconnect the cables from the Film Enc and Film Mtr connectors on the DACQ and feed them through the hole in the bulkhead. It may be necessary to remove the grommet from the hole in the bulkhead.

Remove the drive belt.

Loosen the set screw that secures the pulley to the drive shaft.

Remove the pulley from the drive shaft. You now have access to the screws securing the motor assembly to the adjusting plate.

Remove the three or four (depending on the rev) screws securing the motor assembly to the adjusting plate.

Remove the drive motor/encoder.

REPLACEMENT

The Drive Motor/Encoder Assembly should be replace in the reverse order that it was removed, taking care to replace the grommet and securing the cables with tie wraps.

SCHEMATICS AND DRAWINGS

PART NUMBER	DESCRIPTION
0070-578	TREE, PRODUCT, LS135
0071-317	DIAG, AC & DC WIRING, LS135
0071-318	DIAG, SYSTEM INTCON & PWR DISTRIBUTION, LS135
0070-679	SCH, REF LED, SCRN PRES1, V2
0070-235	SCH, DCB3, V1, LSDT
0068-855	SCHEMATIC, GALVO DRIVER V5, LSDT
0071-552	SCH, BLUE LED/ISFILM, LS135
0070-254	SCH, PMT PREAMP, V1, LSDT
0071-997	SCH, DATA ACQUISITION BOARD 4, V1, LS135B

APPENDIX A: LUMISCAN ACR-2000 Reader JUMPER AND SWITCH SETTINGS

Identifying your Data Control Board (DCB)

There are three versions of the DCB in existence. The newer DCB3 has slightly different switch settings than the DCB1 or DCB2. Here’s how to identify them:

Ver	Size		IRQ	Address DIP Switch	Memory Address	Base I/O Address	Memory Size
DCB1	Big	(13” long)	JP1	S1 (6 bits)	S1-1 thru S1-5	S1-6	N / A
DCB2	Med	(9” long)	JP2	S1 (6 bits)	S1-1 thru S1-5	S1-6	N / A
DCB3	Small	(6” long)	JP2	S1 (8 bits)	S1-1 thru S1-5	S1-6 thru S1-7	S1-8

Changing IRQ Level

The **LUMISCAN 50 / 75 / 85** is factory configured to use IRQ level 5. The IRQ level may be changed by setting a jumper on the Data Control Board (JP1 or JP2, see table above). To change the setting, remove the jumper from its current position and move it to the desired level.

```
   JPx  (see above table)
0  0  0  0  0
      |
0  0  0  0  0
3  4  5  6  7
   IRQ
```

If the IRQ is changed from level 5 you MUST inform the driver when it is loaded. This is accomplished by using a switch. The switch is a forward slash (/) such as used with MS-DOS commands. The format is /Ix, where x is the IRQ level. For example, to install the driver using IRQ 6 from the MS-DOS prompt you would enter ***"LSDTVxxx /I6".***

Changing Window Address

The **LUMISCAN 50 / 75 / 85** is factory configured to use a 32-Kbyte window starting at address D0000 and ending at D7FFF. The upper 5 bits of the address are set with the 6-position ADDRESS SELECT SWITCH (S1-1 through S1-5) on the DATA CONTROL BOARD (DCB), switch position S1-6 is used to set the BASE I/O ADDRESS.

NOTE: If the DCB is changed from its default address of ***D0000***, you must add the **/Mxxxx** switch to the driver load command to provide the driver the new 4-digit "SEGMENT ADDRESS". The command would like this:

```
C:\LSDT\TOOLS\LSDTVxx  /ME000
```

The following table shows how to set this switch to achieve the desired address.

ADDRESS	S1-1	S1-2	S1-3	S1-4	S1-5	COMMENTS
A0000	ON	ON	OFF	OFF	OFF	Normally used for VGA Cards
A8000	OFF	ON	OFF	ON	OFF	Normally used for VGA Cards
B0000	ON	OFF	OFF	ON	OFF	Normally used for VGA Cards
B8000	OFF	OFF	OFF	ON	OFF	Normally used for VGA Cards
C0000	ON	ON	ON	OFF	OFF	Normally used for VGA Cards
C8000	OFF	ON	ON	OFF	OFF	
D0000	ON	OFF	ON	OFF	OFF	Default Setting for DCB
D8000	OFF	OFF	ON	OFF	OFF	
E0000	ON	ON	OFF	OFF	OFF	
E8000	OFF	ON	OFF	OFF	OFF	

NOTE: If the address is changed, care must be taken to select an address range which is not being used by another device. The most significant bit of the address is controlled by switch position S15. Lumisys supplies a utility program, **FINDMEM**, which can be used to identify potential open address locations in the range A0000-EFFFF. **FINDMEM** has the following output format:

```
C:\LSDT\TOOLS>FINDMEM

A000:0000   --USED--  A000:0000 = 20
A800:0000   --USED--  A800:0000 = 20
B000:0000   --USED--  B000:0000 = 4D
B800:0000   --USED--  B800:0000 = 20
C000:0000   --USED--  C000:0000 = 55
C800:0000   --USED--  C800:0000 = 4D
D000:0000   **FREE**
D800:0000   --USED--  D800:0000 = 5A
E000:0000   --USED--  E000:0000 = B4
E800:0000   --USED--  E800:0000 = 41
```

EMM386.EXE and your CONFIG.SYS

Whichever DCB memory address is used, your CONFIG.SYS should be modified to exclude the DCB Memory Mapped Address range from use by EMM386.EXE. The following line is normally used:

```
DEVICE=C:\DOS\EMM386.EXE   NOEMS  X=D000-D7FF
```

Changing the BASE I/O ADDRESS

Switch S1-6 is used to control the BASE I/O ADDRESS**.** Either S1-6 or both S1-6 and S1-7 are used, according to the DCB model:

Ver	Base I/O Address
DCB1	S1-6
DCB2	S1-6
DCB3	S1-6 thru S1-7

Placing the switch (or switches) in the factory default position OFF position selects the **FACTORY DEFAULT I/O ADDRESS 100.** Setting the switch (or switches to the ON position selects I/O ADDRESSES 120, 140 or 160, according to the DCB model. When not in the factory default position, the **/B** switch must be added to the driver load command. For example:

```
\LSDT\TOOLS\LSDTVxx  /B120
```

How to set this switch to achieve the desired address for a DCB1 or DCB2:

BASE I/O ADDRESS	S1-6
100	OFF
120	ON

How to set this switch to achieve the desired address for a DCB3:

BASE I/O ADDRESS	S1-6	S1-7
100	OFF	OFF
120	ON	OFF
140	OFF	ON
160	ON	ON

Changing the MEMORY SIZE

For DCB3s, switch S1-8 is used to specify the size of the installed memory:

MEMORY SIZE	S1-8
4 MBytes	OFF
16 MBytes	ON

FILEXFER PROCEDURE

1.1.1. Using FILEXFER to transfer files to and from the Internal SCSI board

Files can be transferred to and from the SCSI board using the FILEXFER program. The transfer is done through the SCSI bus instead of the serial port.

Transferring files *FROM* the SCSI board *TO* the Host computer:

1) Make sure LSDTISO is running on the internal SCSI.
2) Open a command window on the host computer and change the directory to \LSDT32\TOOLS.
3) Enter **filexfer /r [source file] [destination file]**

Note: The source file is the name of the file on the SCSI board. Be sure to enter the drive letter with the file name. For example, to transfer the clut file cltXXXXX.dat from the flashdisk (d: drive) to the host, enter **filexfer /r d:cltXXXXX.dat cltXXXXX.dat**. The destination file is the name of the file for the host computer. The path is optional, the default path is the current directory.

4) The status will display once the transfer is complete.

Transferring files *TO* the SCSI board *FROM* the Host computer:

1) Make sure LSDTISO is running on the internal SCSI.
2) Open a command window on the host computer and change the directory to \LSDT32\TOOLS.
3) Enter **filexfer /w [source file] [destination file]**

Note: The destination file is the name of the file on the SCSI board. Be sure to enter the drive letter with the file name. For example, to transfer the clut file cltXXXXX.dat to the flashdisk (d: drive) from the host, enter **filexfer /r cltXXXXX.dat d:\cltXXXXX.dat**. The source file is the name of the file for the host computer. The path is required if the file is not in the current directory.

4) The status will display once the transfer is complete.

ACR 2000 Calibration Procedure

1. *Optical*

a. Ensure that there is no obstruction of the optical pathway. Dirt on the mirrors, artifacts in the collection chamber entrance or exit, and stray cable ties will cause problems during image acquisition. A laser cheater key is required to enable the laser to illuminate.

b. Disconnect J3 at the Galvo-driver board. Check laser output at entrance to chamber and at the source with laser tester in order to determine that the laser path is clear. Output should be ~18mW at the collection slot. (If laser is dim run DDT20(c:\lsdt32\tools\ddt) to check laser is not operating in 10% standby Mode)

c. With J3 disconnected from the Galvo board, check that the laser is centered in the collection slot +/- 0.25”… Reconnect J3.

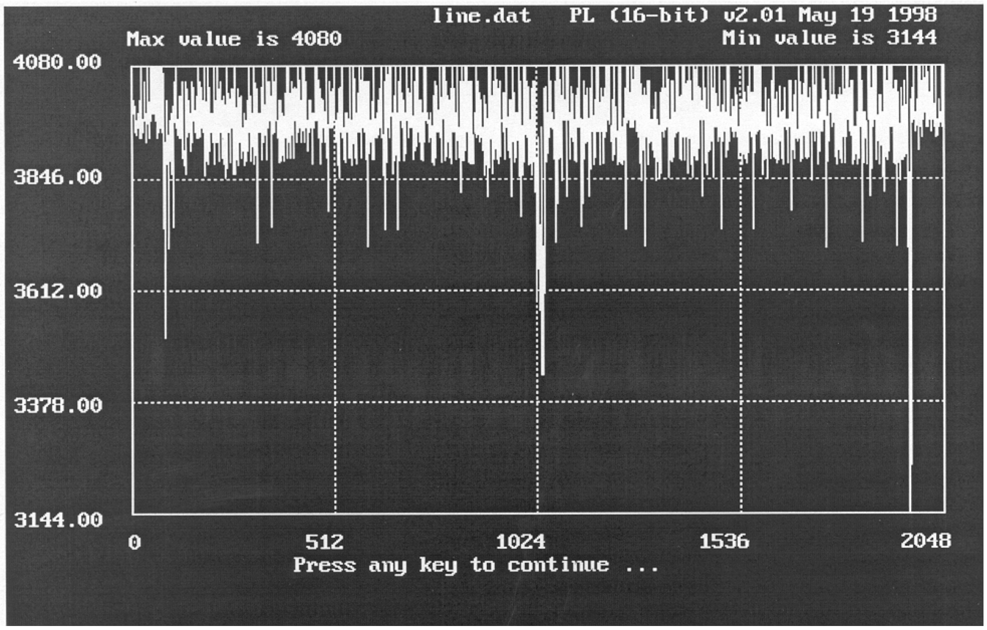
d. Run DDT 10 (c:\lsdt32\tools\ddt) and ensure the laser sweep is across the entire slot, and overlap of 1.5” left and 2.5” right. If initial linearity check is out of limits use Span (R59) and Offset (R58) on the DACQ.

2. *PMT Adjustments*

a. Disconnect PMT high voltage J14 (DACQ) and check for 0 volts at TP9(DACQ), If not adjust R8(PMT PRE-AMP) for 0 volts at TP1(PMT PRE-AMP) and check TP9(DACQ) for 0 volts again(+/- .1mV). Reconnect PMT High Voltage J14(DACQ).

b. Cover the ACR 2000 with a photographic cloth and have dim room lighting with no shadows.

c. Run DDT 10 (c:\lsdt32\tools\ddt), than enter “P”, The display should appear:



```
                         line.dat   PL (16-bit) v2.01 May 19 1998
      Max value is 4080                                Min value is 3144

                  Press any key to continue ...
```

3. ***Setting PMT Gain***

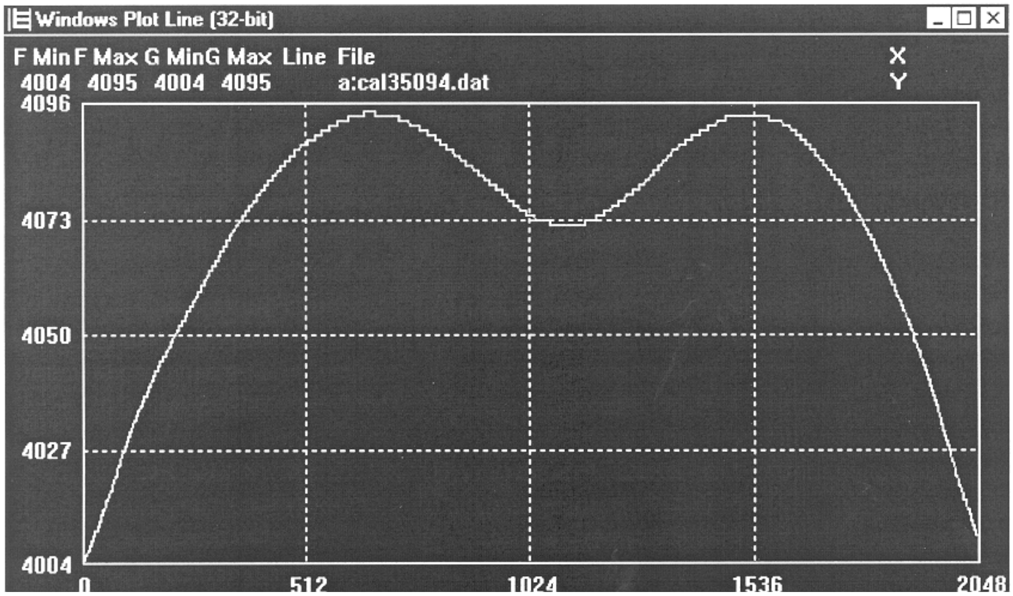
a. Using an erased image plate expose it to a uniform 8mR exposure (~8mAS at 85kVP at 71"SID). Insert the exposed image plate into the film slot. Ambient light must be kept to a minimum for this test. Run DDT 16 followed by DDT 26 (c:\lsdt32\tools\ddt), than press M to start the drive motor, select 1956.
b. When the image plate reaches the slot the counts should drop from above 3600 to a lower number. Adjust R140 (DACQ) to give a mean count of 660+/- 20 counts. This needs to be completed before the plate falls through the slot, otherwise the process will need to be repeated.
c. (Blue LED adjustment) Run DDT 20 (c:\lsdt32\tools\ddt) the initial counts should be over 3600 indicating no signal. Press "B" this will turn on the Blue Reference LED. Adjust R2 (Blue LED Reference Board) to set the peak counts to 1071. This provides the AGC control signal used as a reference point for the PMT before each scan.

4. ***PMT Balance***

a. Using an erased image plate expose it to a uniform 4mR exposure, (place a 1mm copper filter over the collimator ~4mAS at 85kVP at 71"SID). Verify with a dose meter that the dose is 4 +/- 0.05mR. Be sure the collimator shutters are oped sufficiently to expose the entire image plate.
b. Minimize the ambient light as mush as possible and cover the system with a dark cloth.
c. Place the exposed image plate into the feed slot.
d. Connect the Oscilloscope Channel 1 to the top pin of TP9(DACQ), Connect the Trigger to the top pin of TP8(DACQ), set the trigger to –slope and the sweep to 2mS/DIV.
e. Run DDT 16 (c:\lsdt32\tools\ddt) followed by DDT 20, Press "M" to start the drive motor. When prompted enter "1956" to set the motor speed.
f. Observe the 2-peaks in the waveform. The left peak is the left PMT as you are facing the Reader. The right peak is the right PMt as you face the Reader. If the peak's are not balanced use the potentiometer on top of the PMT's, adjust the higher amplitude PMT to match the amplitude of the lower PMT. If the lower PMT cannot match the higher PMT than both PMT's need to be replaced.

5. ***Create a Calibration LUT***

a. Ensure all panels and covers are replaced, cable tied away from the laser path.
b. In LSDT Control Panel, CR Tab change select the “None” radio button in the Calibration LUT box. Click OK or Apply.
c. Expose a image plate to 4mR~85kVP at 71”SID.
d. At the C:\lsdt32\tools\prompt type MKCALTBL ssss (Where s is the Reader serial number)
e. Allow th batch file to scan the plate and create and install the new CAL file and examine the results.



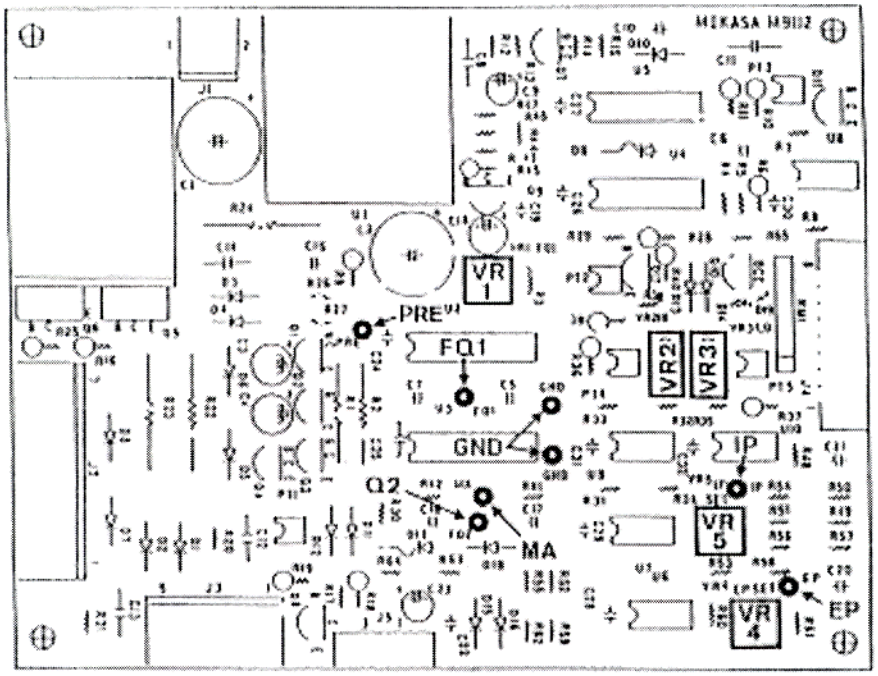
F Min	F Max	G Min	G Max	Line	File
4004	4095	4004	4095		a:cal35094.dat

f. In the LSDT Control panel, on the CR tab change select the “Load from file” radio button in the Calibration LUT box. Ensure that the file you just created is selected. Click OK or Apply.
g. Make a backup copy the new Cal File to a floppy disk with the CLUT file.

MINXRAY HF100H Calbration

This adjustment has to be done after connecting all connectors completely. Actual x-ray exposure is not necessary

Each PC Board delivered from the factory has been already adjusted



M9112 PC Board adjustment

1. Adjustment of FQ1 Adjust frequency between FQ1 (+) and GND (–) to be 120kHz by turning VR1. Turning clockwise increases frequency.

2. Confirmation of FQ2 Confirm if frequency between FQ2 (+) and GND (–) is 90kHz ±5%. It cannot be adjusted.

3. Adjustment of Pre-heat voltage at 20mA.Adjust voltage between PRE (+) and GND (–) to be 0.43V by turning VR3. Turning clockwise increases voltage.

4. Set VR4 (EP SET) to the center position.

5. Set VR5 (IP SET) to the center position.

Re-adjustment of KVP

NOTE: This adjustment requires that an exposure be made. Please observe all radiation related safety precautions.

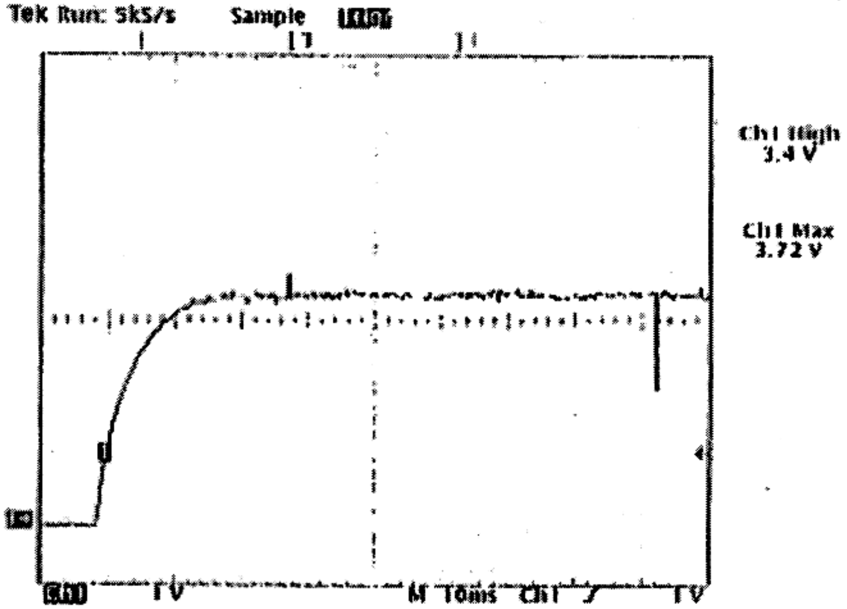
This adjustment should be done whenever Insert Box or Inverter PC Board (M9101B PCB) is replaced.

Oscilloscope Settings: With storage mode, Connect CH1 probe to EP, CH2 probe to IP, and GND to GND terminal on M9112 PC Board. Set the oscilloscope CH1 to 1V/div, CH2 to 0.5V/div, and time to 10msec/div

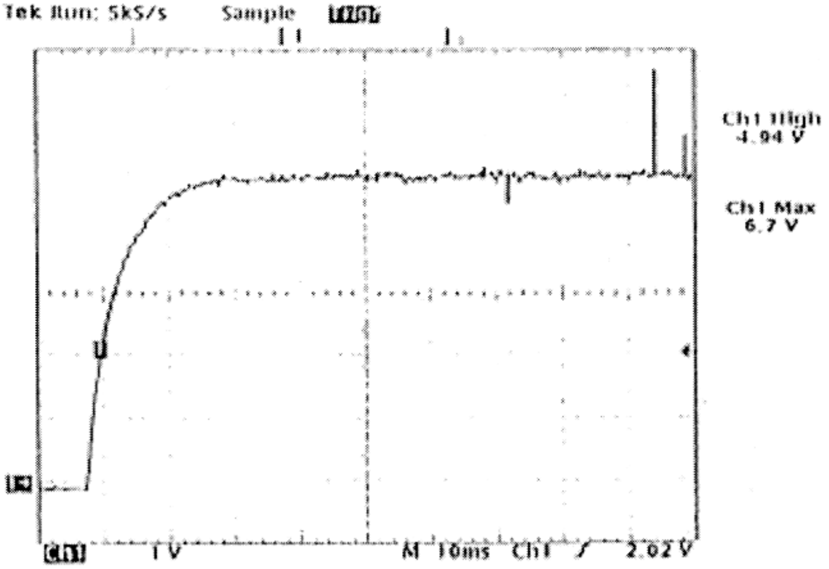
X-ray Unit Settings: 0.1 sec., 70kV

Adjustment: VR4 on M9112 PC Board (EP SET). Measure x-ray tube voltage by oscilloscope and adjust average of peak values of EP waveform to be 3.4V by VR4. After the adjustment is finished, set of device to be 100kV and adjust again so that average of peak values of EP waveform to be 4.9V. When x-ray tube voltage is measured by non invasive direct x-ray measuring equipment such as PMXIII, approx. 3kV of deviation is included. Therefore, adjust kV to be 97.5 99kV at 100kV station.

Adjustment of 70kV by VR4 Adjust the ch1 (Ep) by VR4 to be 3.4V ±0.5V. kV is increased by turning clockwise.



Adjustment of 100kV by VR4 Adjust the ch1 (Ep) by VR4 to be 4.9V ±0.5V. kV is increased by turning clockwise.



Re-adjustment of Pre-heat and mA

This adjustment has to be done after connecting all connectors completely. Actual exposure is necessary.

NOTE : This adjustment requires that an exposure be made. Please observe all radiation related safety precautions.

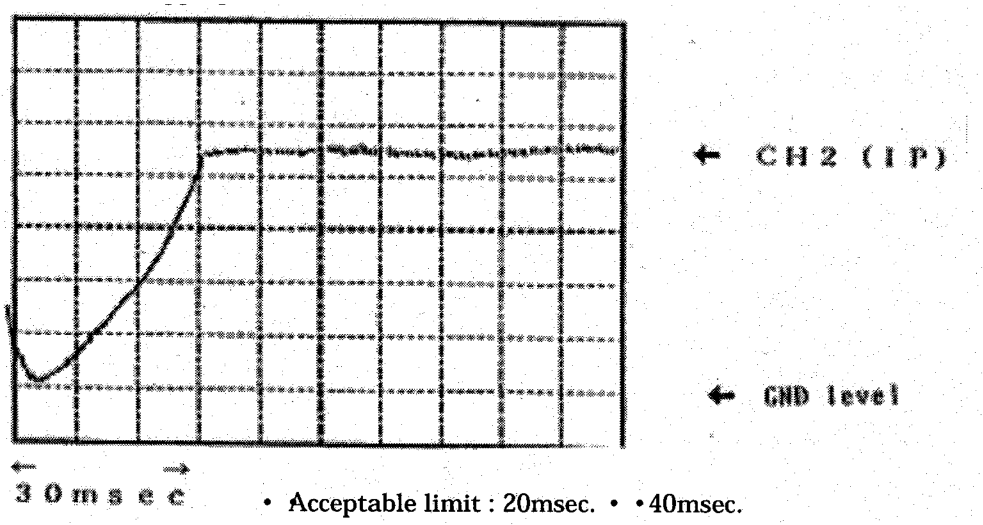
This adjustment should be done whenever Insert Box or Inverter PC Board (M9112 PCB) is replaced.

Oscilloscope Settings: With storage mode, Connect CH1 probe to EP, CH2 probe to IP, and GND to GND terminal on M9112 PC Board. Set the oscilloscope CH1 to 1V/div, CH2 to 1V/div, and time to 10msec/div.

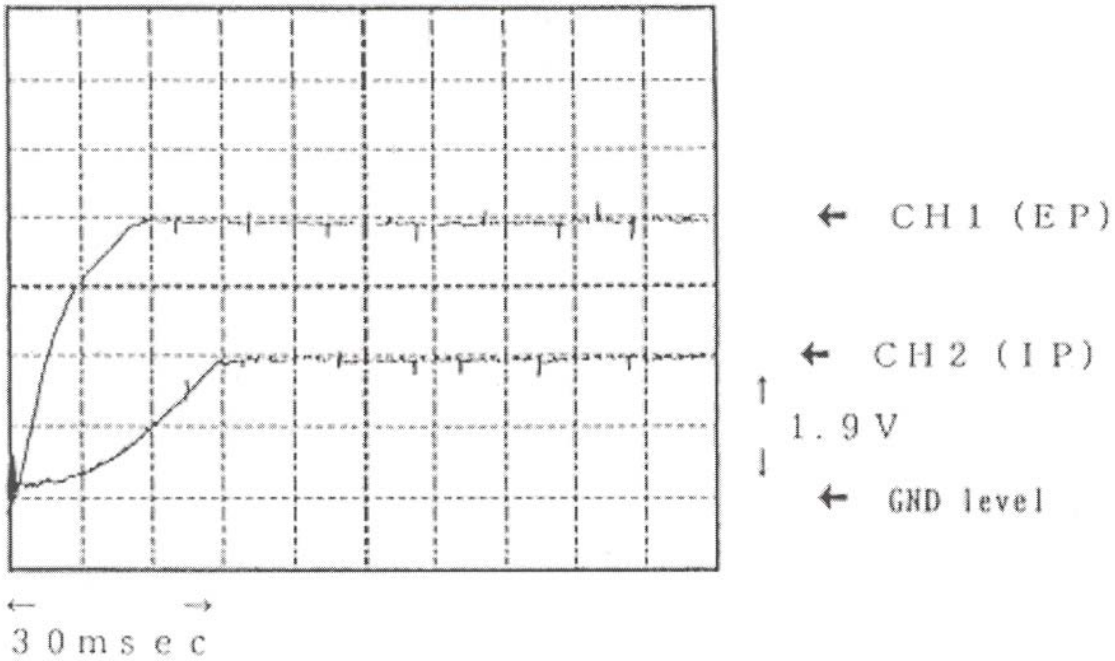
X-ray Unit Settings: 0.1 sec., 80kV

Adjustment : VR3 (Pre-heat voltage) VR5(mA). Set 20mA and adjust to 19mA Pre-heat time, Time should be adjusted to 30msec.±10msec.

Adjustment of Pre-heat time



Adjust the average of peak values of IP waveform to be 1.9V (VR5).



Readjustment of exposure time

This adjustment has to be done after connecting all connectors completely.
Actual exposure is necessary.

NOTE: This adjustment requires that an exposure be made. Please observe all radiation related safety precautions.

Check the exposure time by using an external exposure time meter such as the PMX III.

X-ray unit setting: 82kV 0.5sec

Adjustment: Exposure time is decreased by turning clockwise. VR6 (M3108A PC board)

Relative Gain Adjustment of the ACR-2000

PURPOSE

This procedure details the method to adjust the gain of an ACR-2000 relative to its current gain.

ITEMS NEEDED

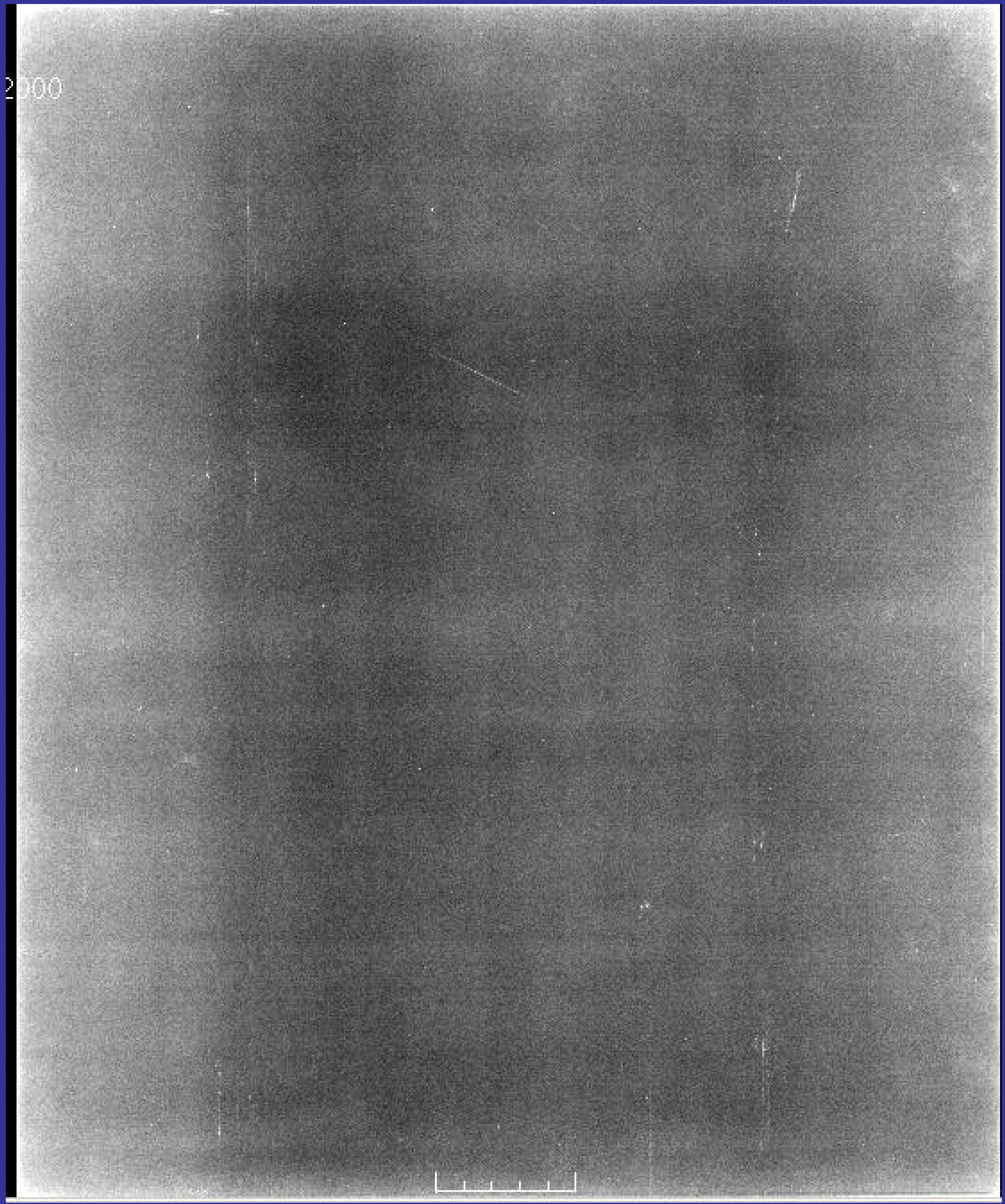
- Philips screw driver
- Dark cloth
- 8mR data value
- Small flathead potentiometer driver
- Dim room
- ACR-2000 Service Manual

PROCEDURE

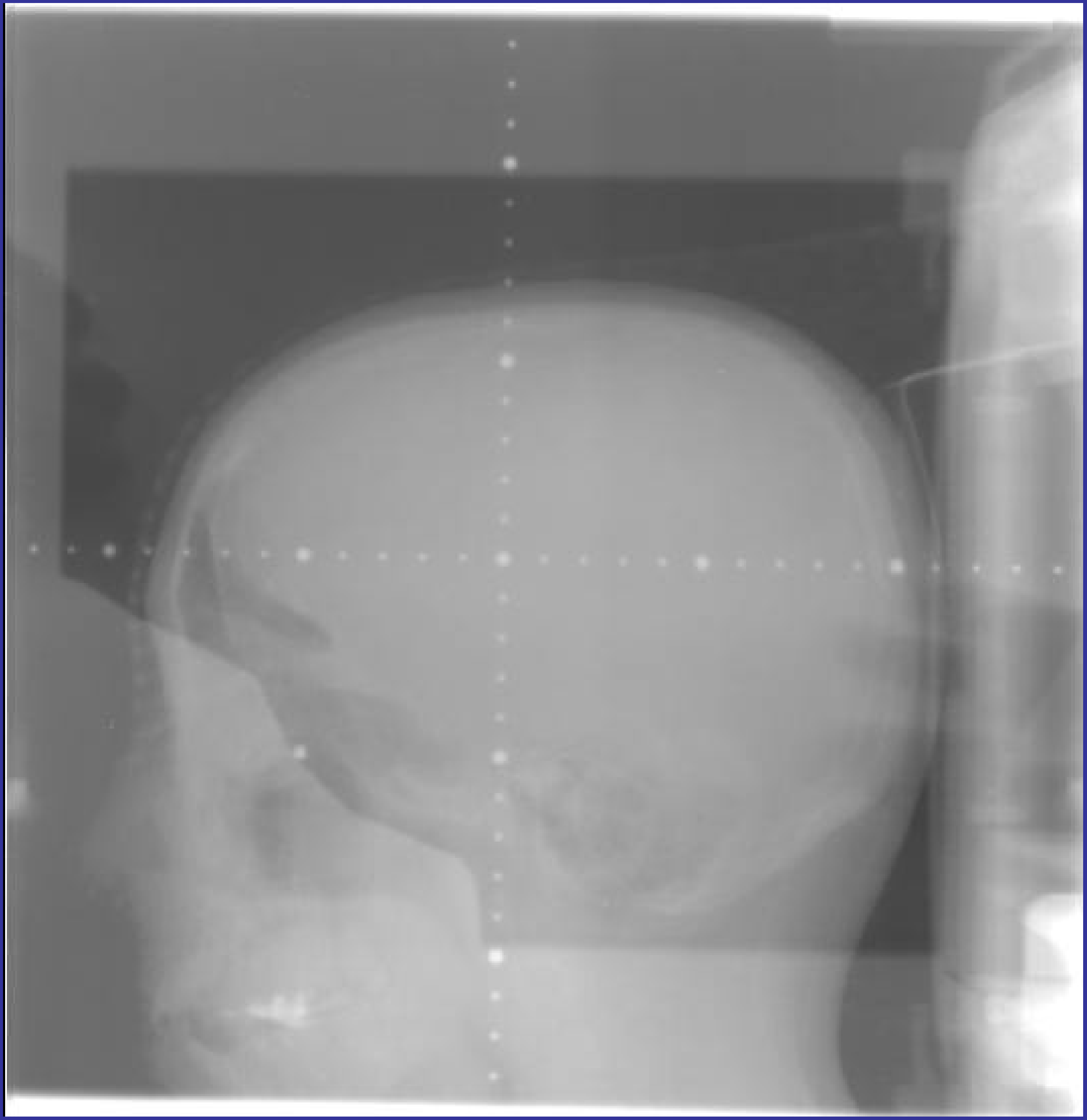
1. The rear cover must be removed to gain access to the adjustment pots and test points. The unit must be kept in a darkened environment and covered with a dark cloth to prevent stray light from affecting the measurements.
2. Turn the unit on and let it stabilize for a few minutes. Open a Command Prompt (MS-DOS) window and run DDT.
3. Select option 10 or 20 and note the Min counts. If they are not 4095 or close to it there may be a light leak.
4. It is necessary at this point to know the data count of the ACR-2000 when measure a plate exposed to 8mR using the method described in Chapter 5 of the ACR-2000 Service Manual. If this information in known, it is not necessary to perform this measurement. Make note of this data count for reference in the following steps.
5. Select option 10 or 20 and hit the B key. This will activate the Blue LED Reference. The Min Blue LED counts should likely drop to near 1071 (+300 /–100) typically. (it will fluctuate)
6. While still running option 10/20 with B, adjust R140 to change the Min counts by the amount of gain change desired. For example, if your 8mR data count is 600, and you want it to be 300, then adjust R140 to DECREASE the Blue LED data counts by 300. Decreasing the Blue LED by 300 counts will double the gain setting of the PMTs.
7. Now adjust the reference LED output to bring the counts back to the original Blue LED count value. This pot is R2 on the Reference LED board, located near the laser interlock switches. This now adjusts the reference to the new gain.

Problem Image Examples

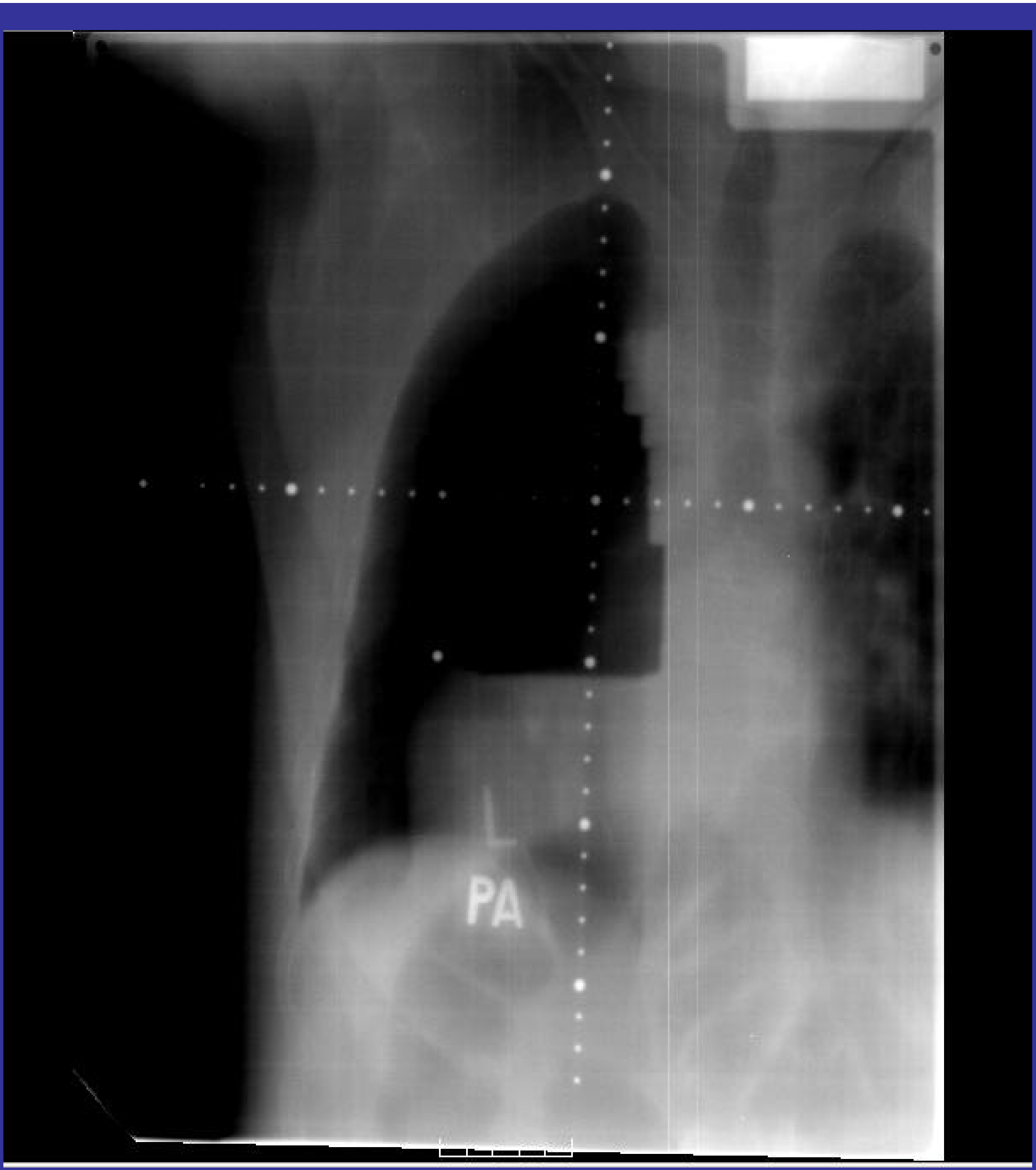
Scratched and dirty plate



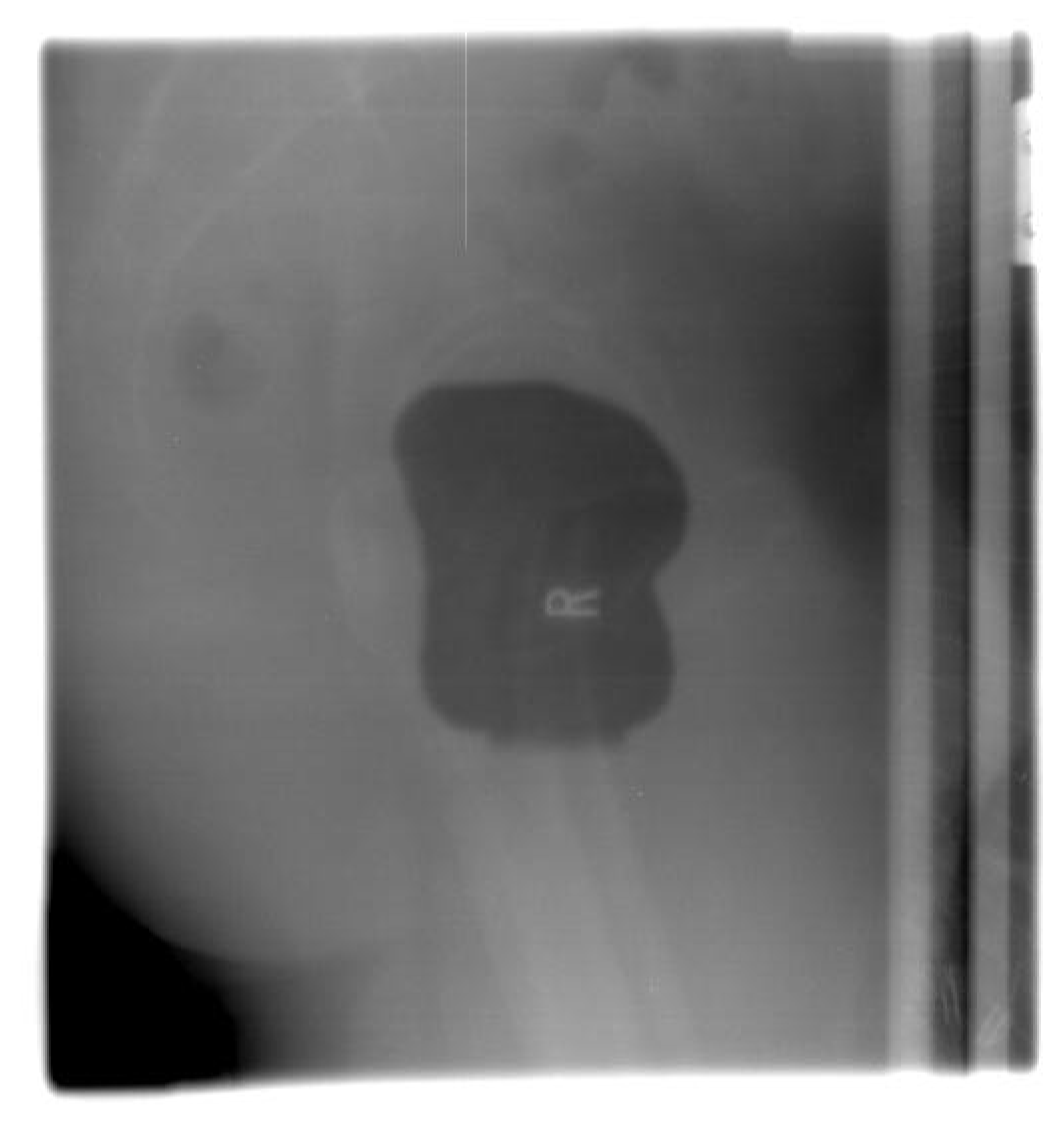
Fingerprints



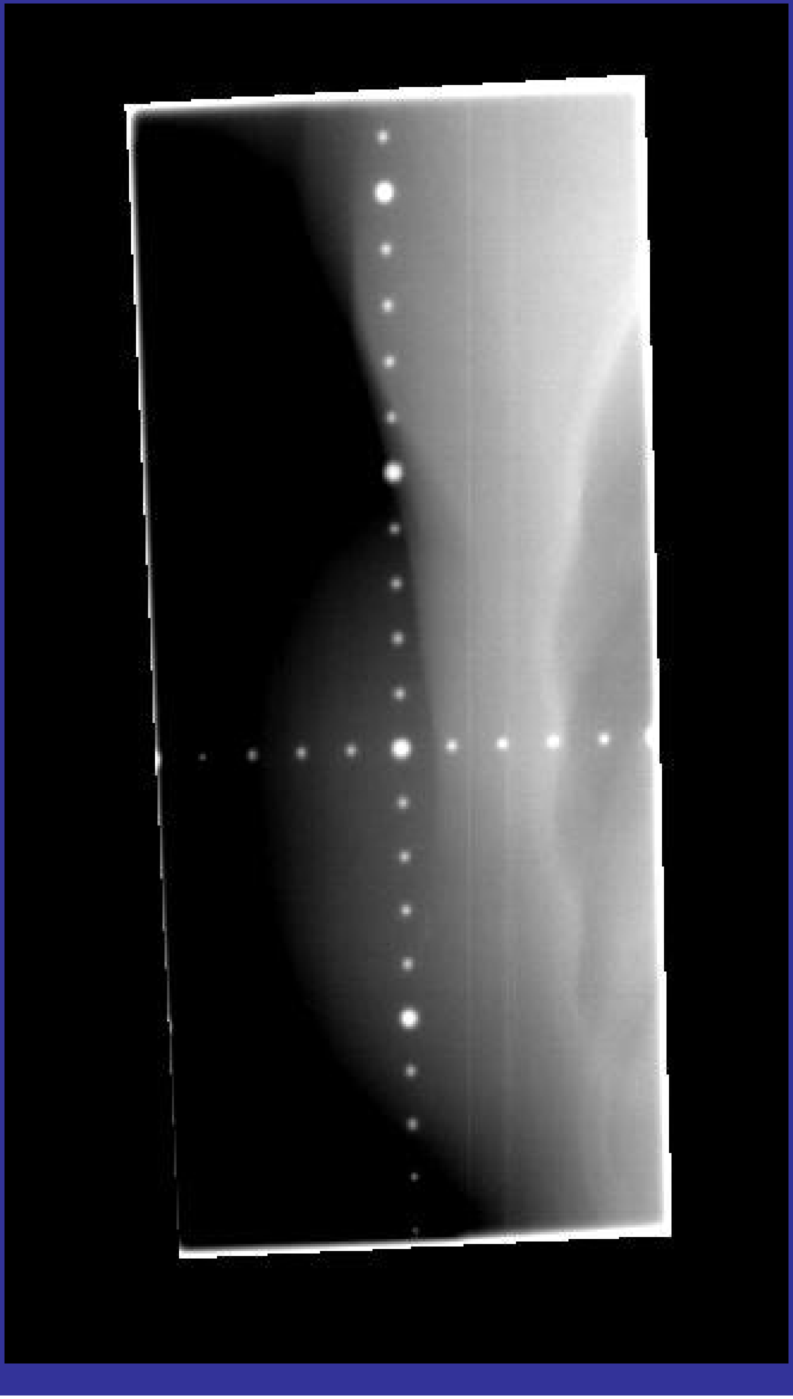
Dust lines



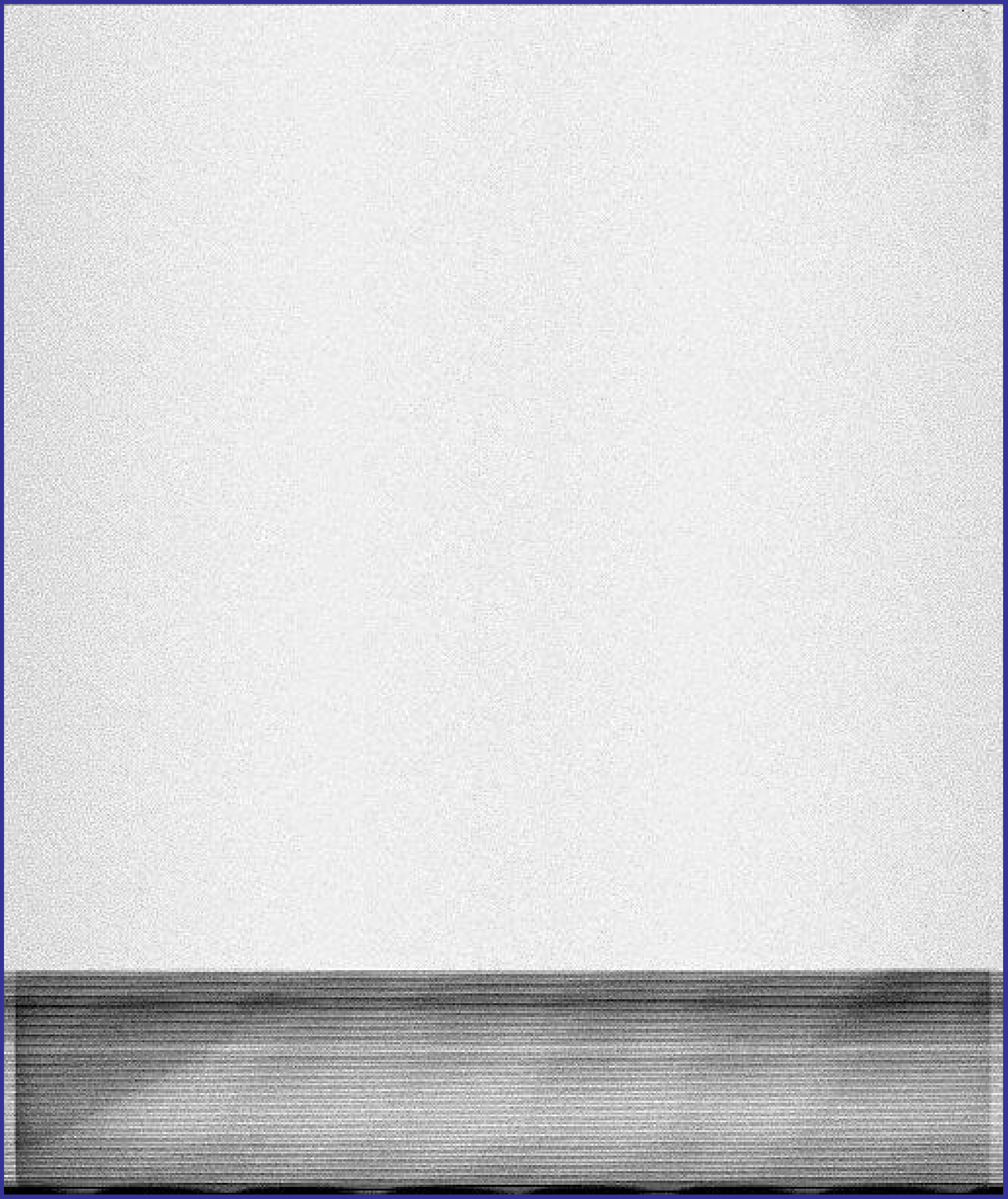
Dust lines



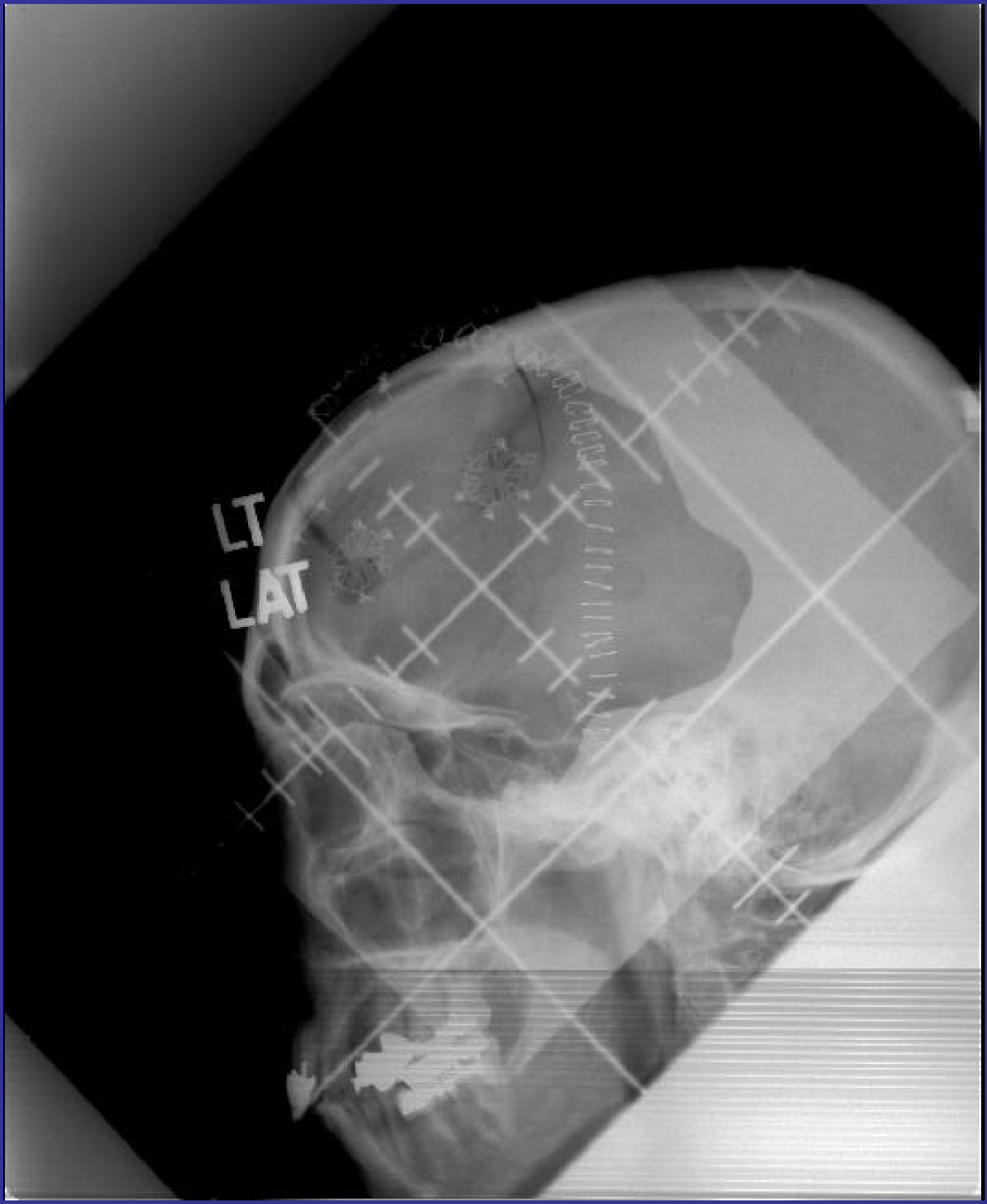
Dust lines



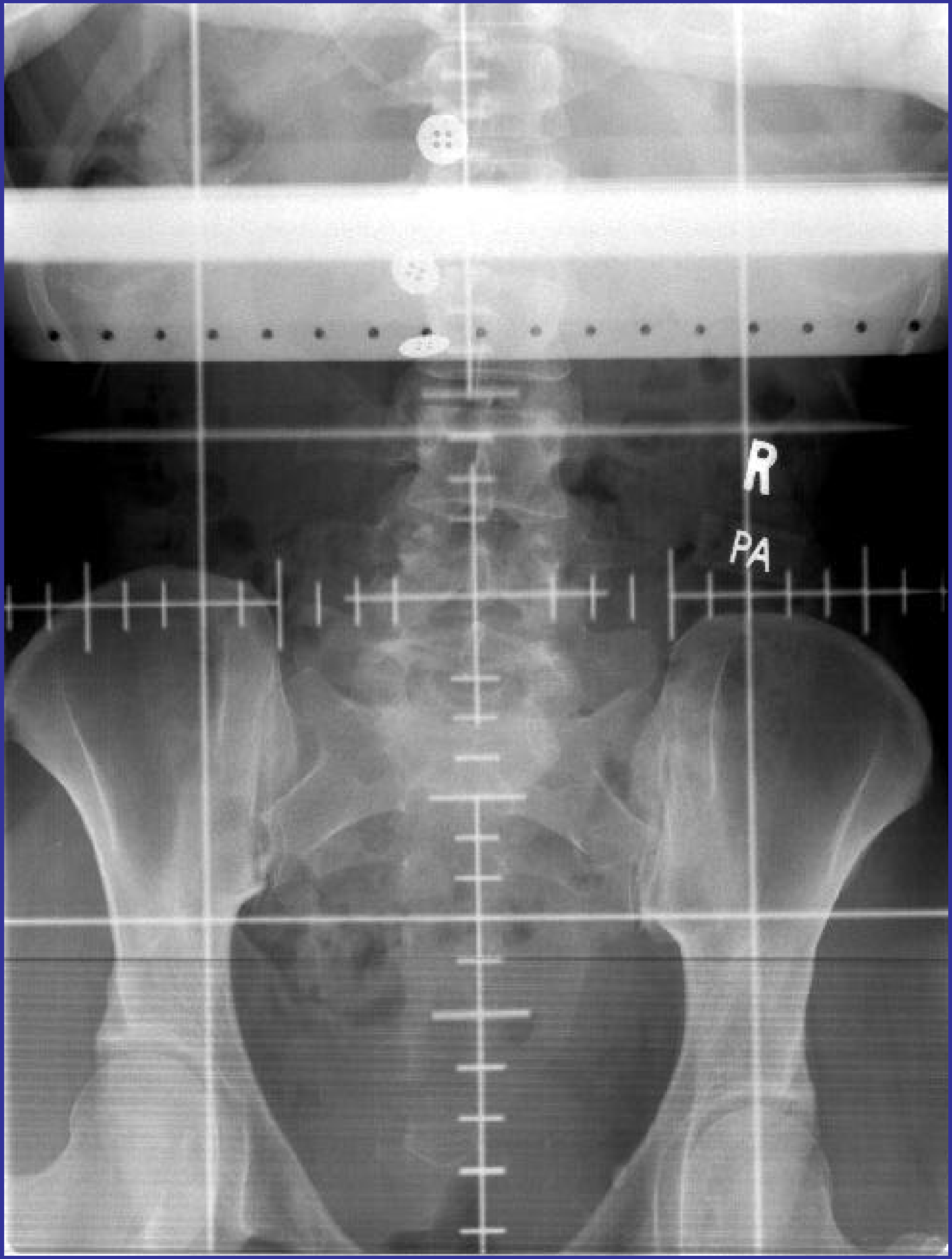
Too much light



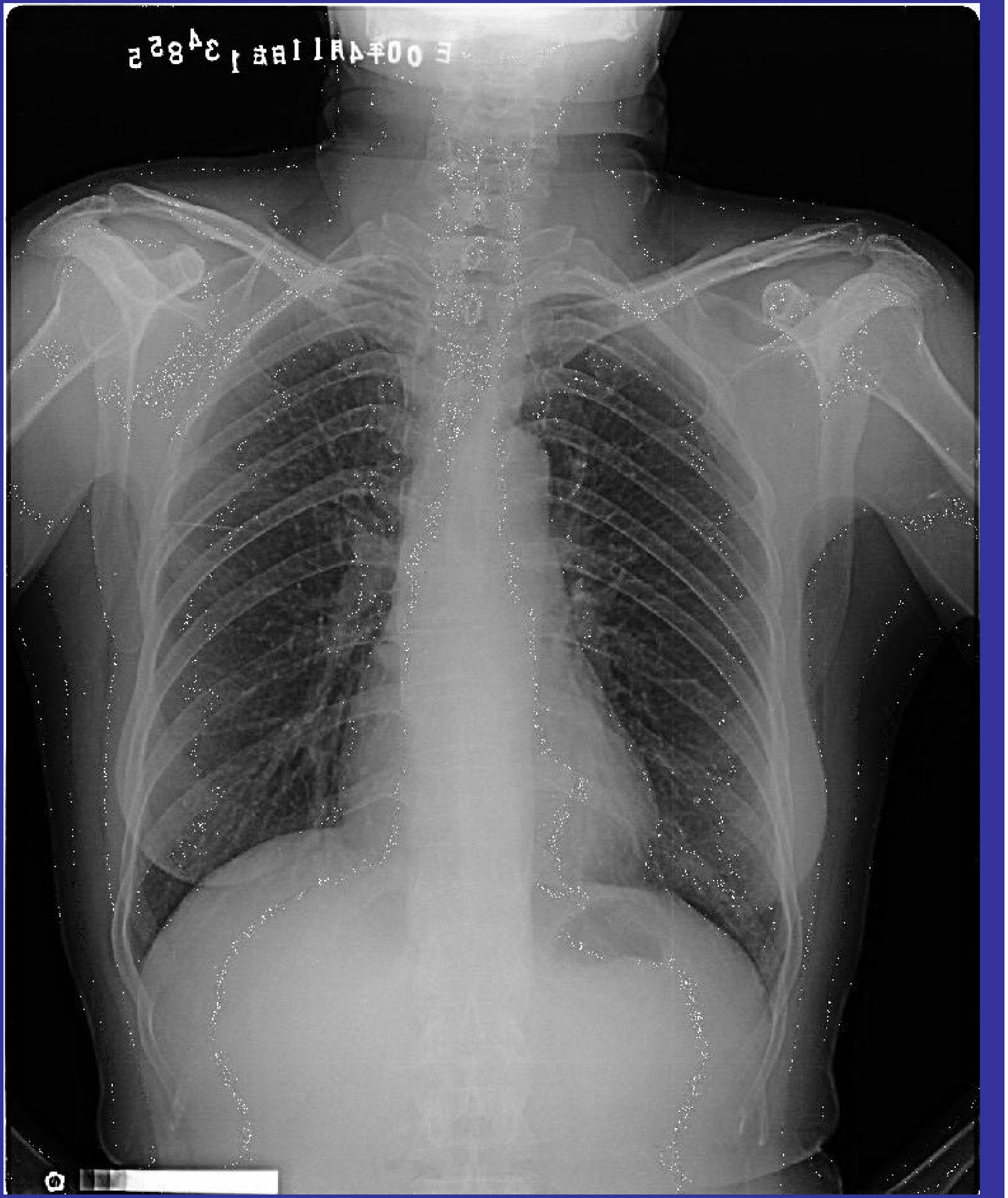
Too much light



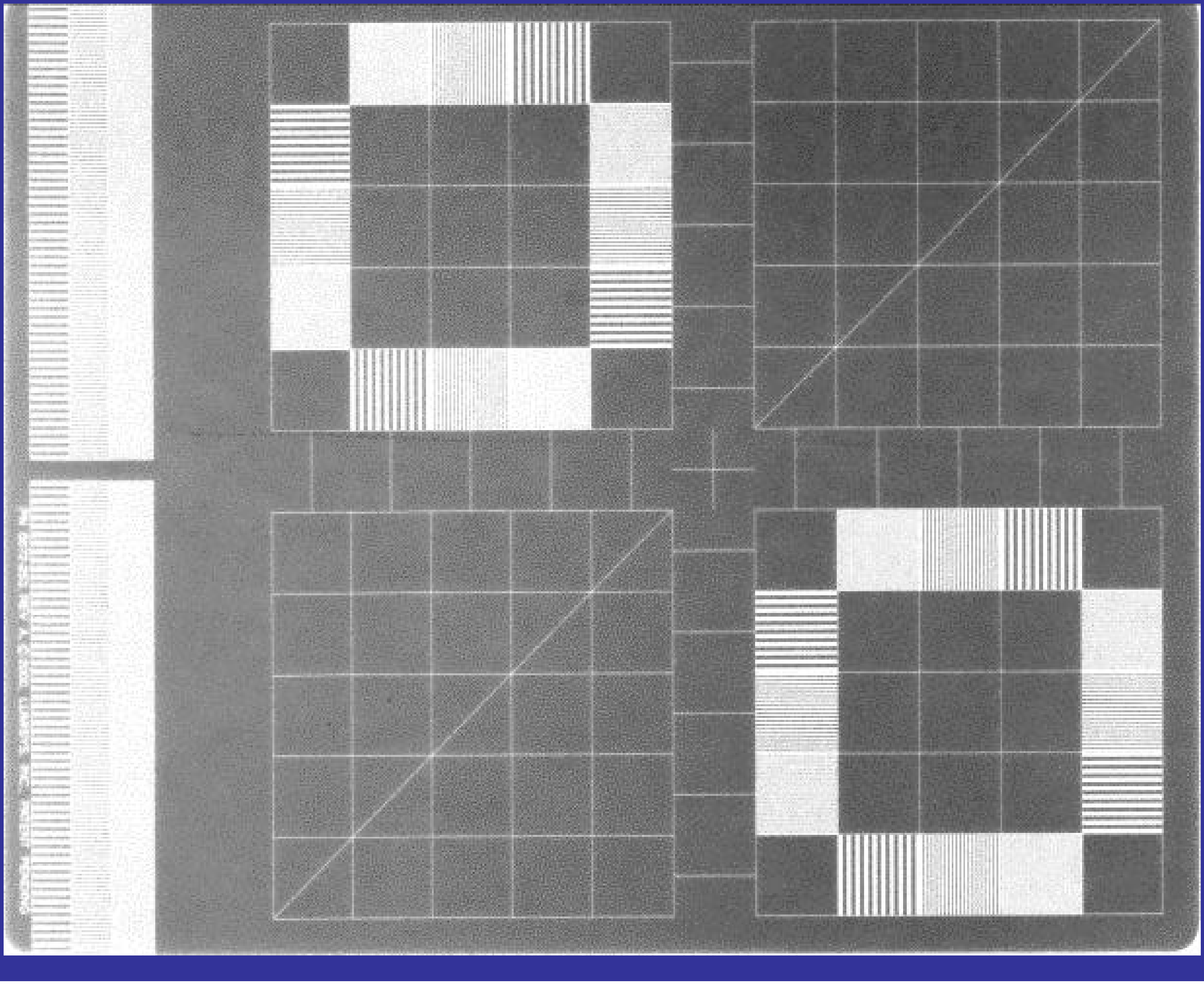
Too much light



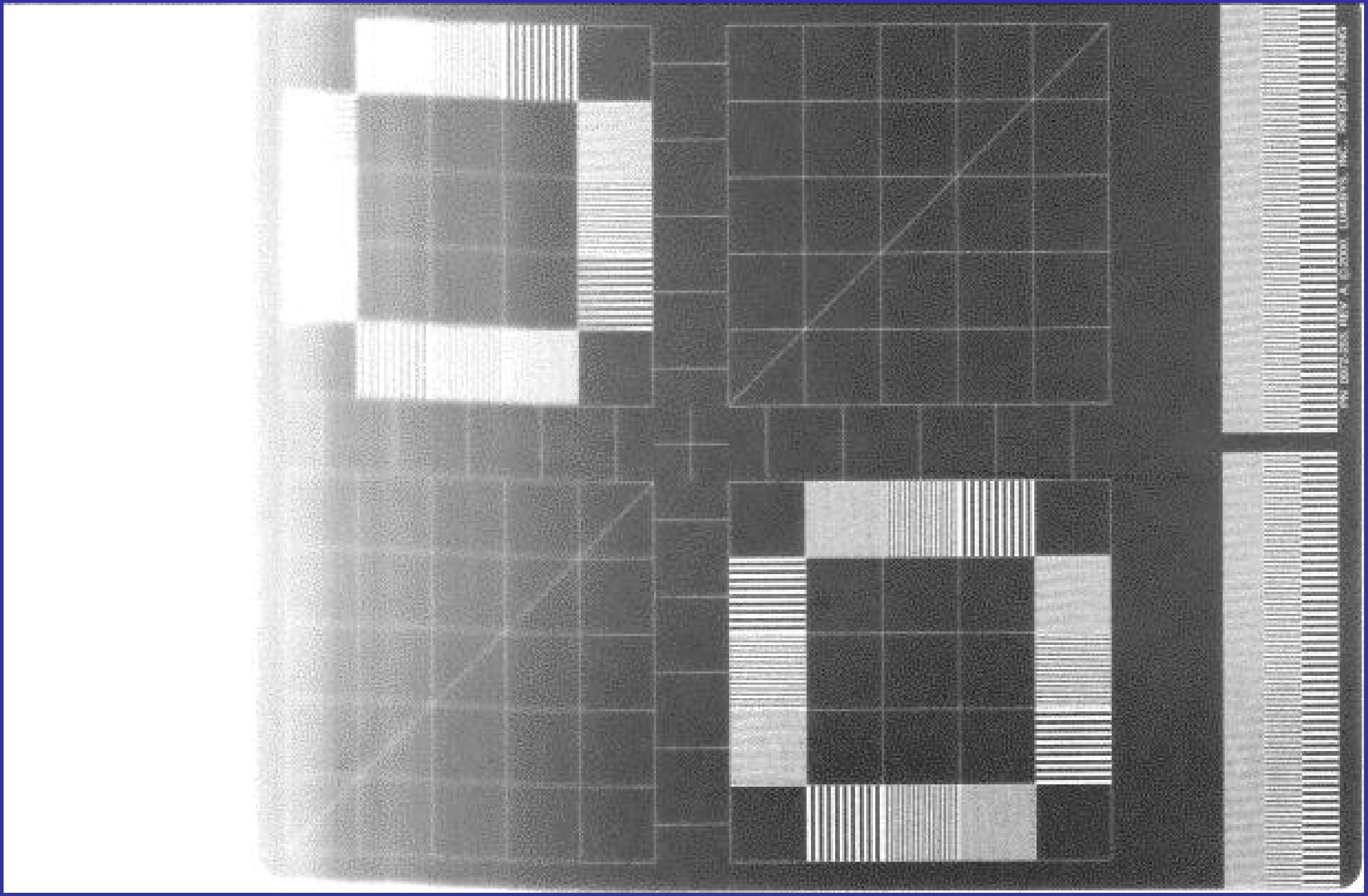
Bad DACQ

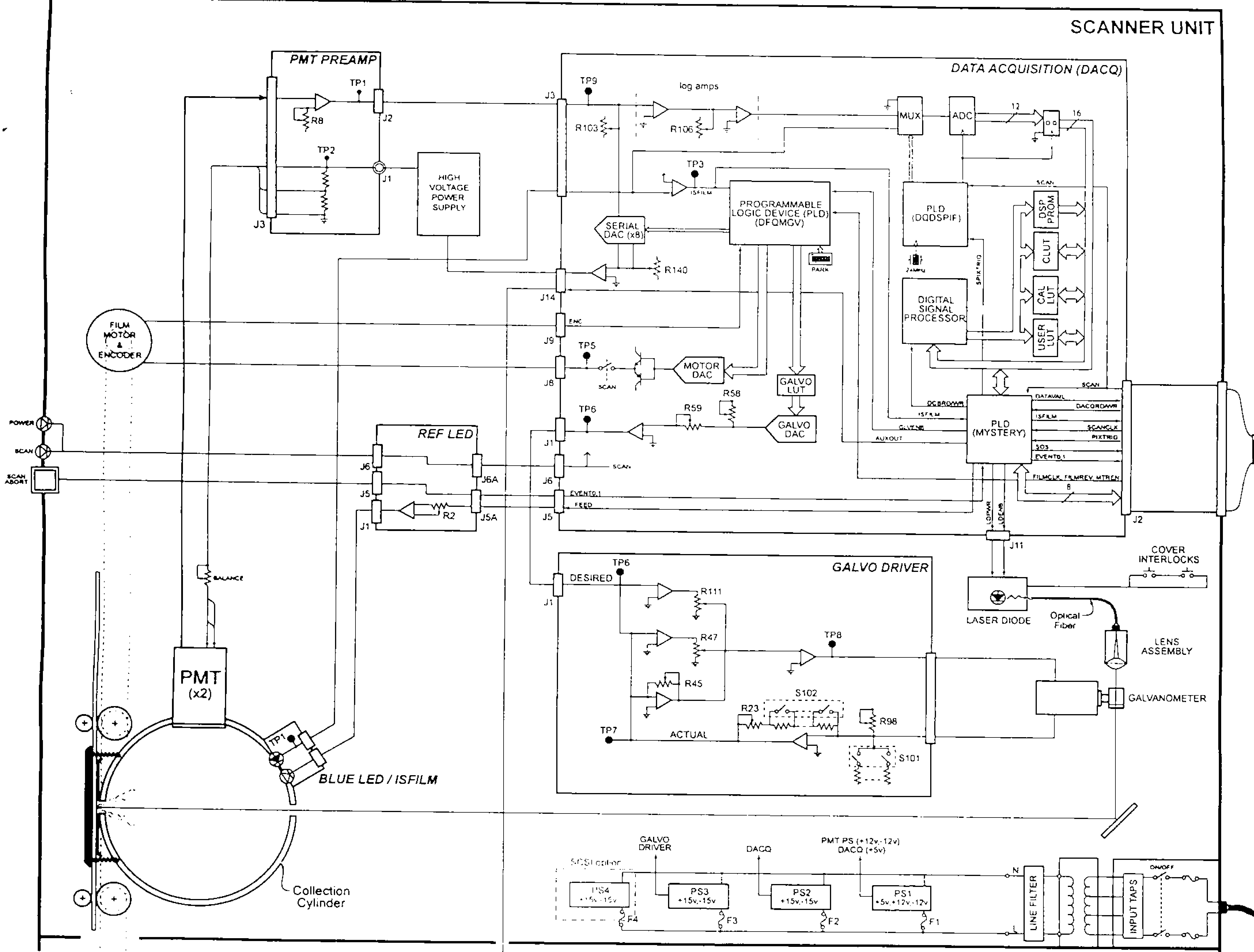


Good Galvo



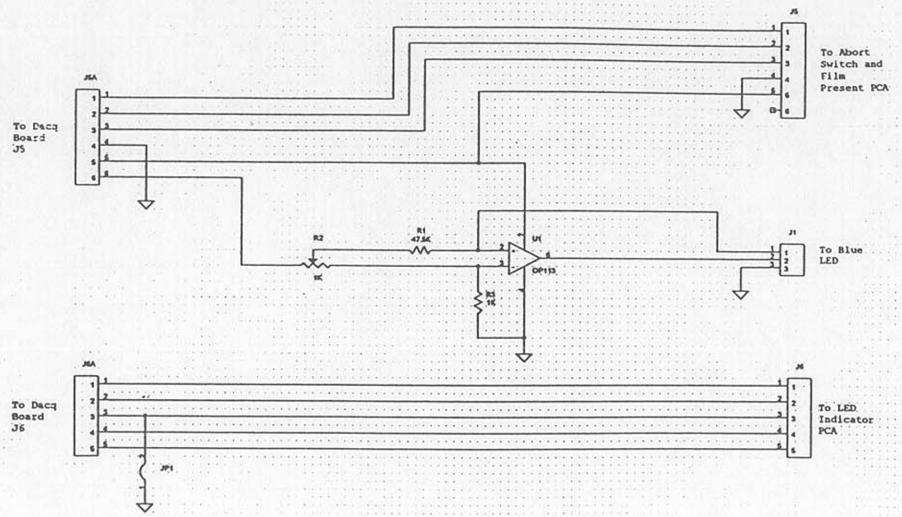
Bad Galvo



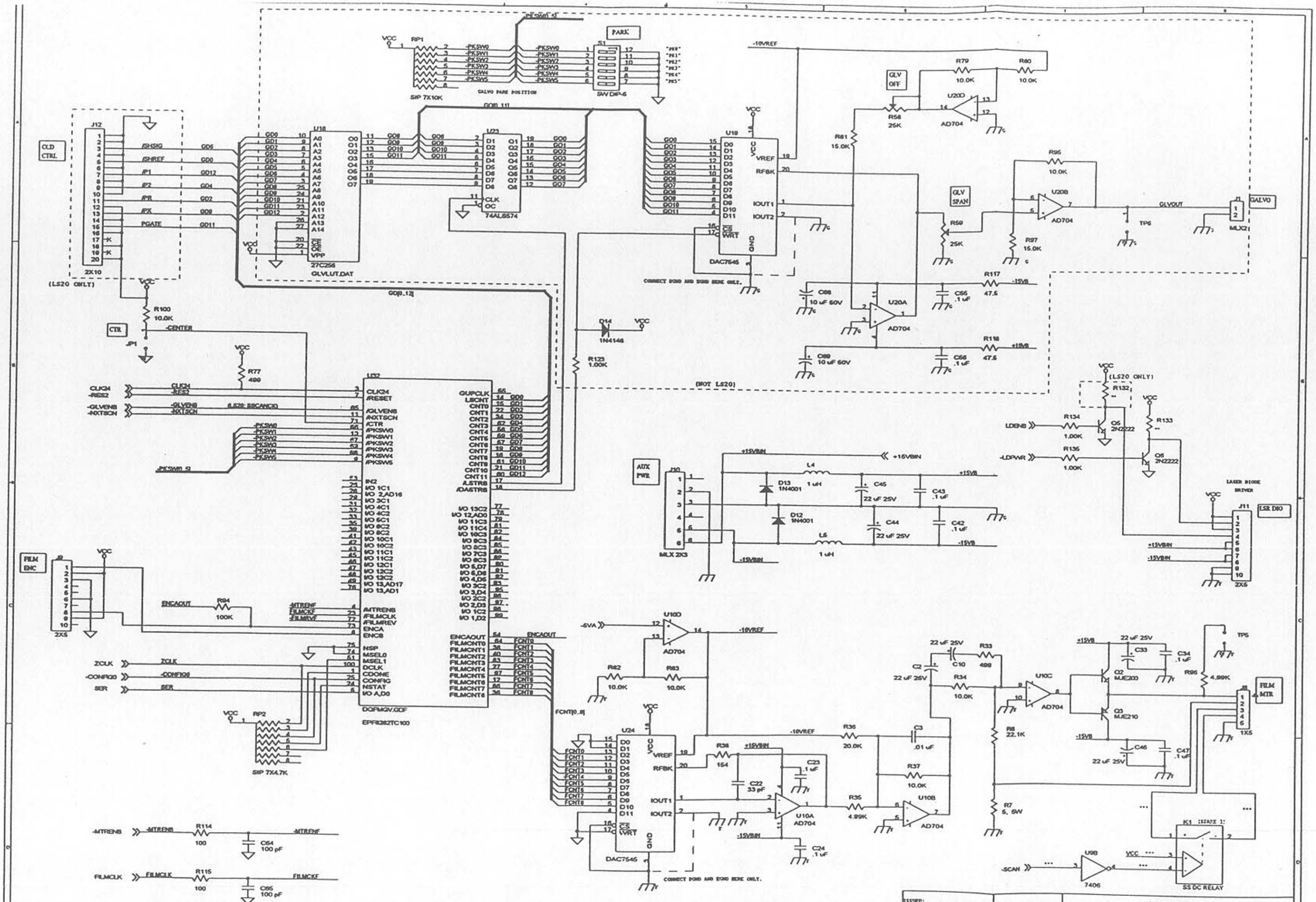

SCANNER UNIT
PMT PREAMP
TP1
R8
J2
TP2
J1
J3
HIGH VOLTAGE POWER SUPPLY
DATA ACQUISITION (DACQ)
TP9
log amps
R103
R106
MUX
ADC
12
16
TP3
ISFILM
PROGRAMMABLE LOGIC DEVICE (PLD) (DFQMGV)
SERIAL DAC (x8)
R140
PARK
PLD (DQDSPIF)
24MHz
SPIXTRIG
DIGITAL SIGNAL PROCESSOR
DSP PROM
CLUT
CAL LUT
USER LUT
SCAN
J14
ENC
J9
FILM MOTOR & ENCODER
TP5
SCAN
MOTOR DAC
J8
GALVO LUT
R58
TP6
R59
GALVO DAC
J1
POWER
SCAN
SCAN ABORT
REF LED
J6
J6A
J5
J5A
J1
R2
SCAN
EVENT0,1
FEED
DCBRDWR
ISFILM
GLVENB
AUXOUT
PLD (MYSTERY)
DATAVAIL
DACORDWR
ISFILM
SCANCLK
PIXTRIG
SOS
EVENT0,1
FILMCLK, FILMREV, MTREN
8
J2
LDPWR
LDENB
J11
COVER INTERLOCKS
GALVO DRIVER
TP6
DESIRED
J1
R111
R47
TP8
R45
S102
R23
R98
TP7
ACTUAL
S101
BALANCE
PMT (x2)
TP1
BLUE LED / ISFILM
LASER DIODE
Optical Fiber
LENS ASSEMBLY
GALVANOMETER
Collection Cylinder
GALVO DRIVER
DACQ
PMT PS (+12v,-12v) DACQ (+5v)
SCSI option
PS4 +15v,-15v
PS3 +15v,-15v
PS2 +15v,-15v
PS1 +5v,+12v,-12v
F4
F3
F2
F1
N
L
LINE FILTER
INPUT TAPS
ON/OFF

REVISIONS

EC	REV	DESCRIPTION	DATE	APRVL
2157	A	PRE-PRODUCTION RELEASE	2/4/98	


J5A
1
2
3
4
5
6
To Dacq
Board
J5
J5
1
2
3
4
5
6
To Abort
Switch and
Film
Present PCA
R2
1K
R1
47.5K
R3
1K
U1
OP113
J1
1
2
3
To Blue
LED
J6A
1
2
3
4
5
To Dacq
Board
J6
JP1
J6
1
2
3
4
5
To LED
Indicator
PCA

ISSUED:		**LUMISYS, Inc.** 225 HUMBOLDT COURT SUNNYVALE, CA 94089	
CHECKED			
DRAWN: JCADOTTE	1/20/98		
APPROVALS	DATE	Title SCH, REF LED, SCRN PRES1, V2	
WHERE USED: LS114/LS135 PCA P/N: 0070-677 PCB P/N: 0070-678 ORCAD FILE: LEDADPT2.DSN		Size C Document Number 0070-679	Rev A
		Date: Sheet 1 of 1	

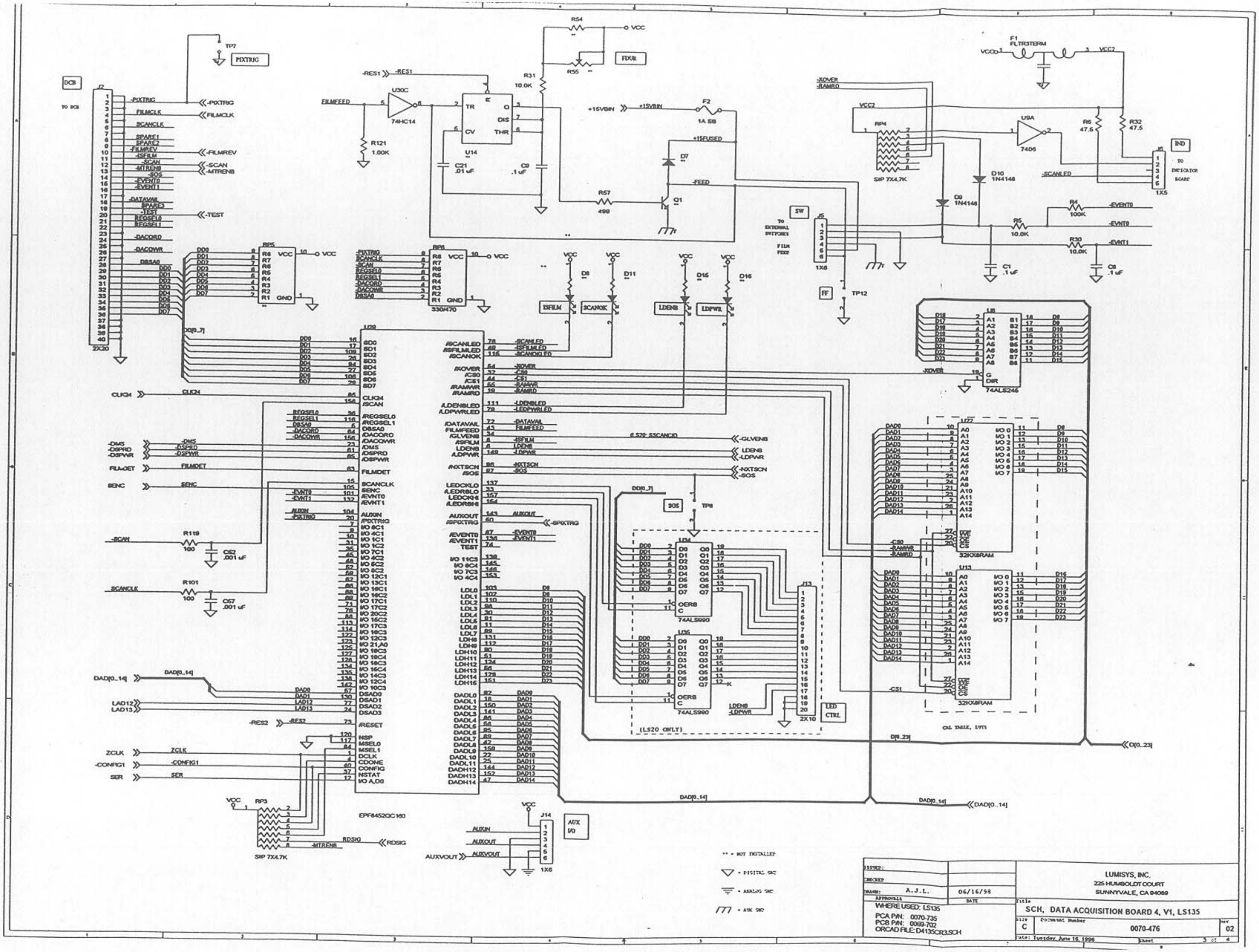

CLD CTRL
J12
2X10
(LS20 ONLY)
/SHSIG
/SHREF
/P1
/P2
/PR
/PX
PGATE
R100 10.0K
-CENTER
CTR
JP1
PARK
RP1
SIP 7X10K
-PKSW0
-PKSW1
-PKSW2
-PKSW3
-PKSW4
-PKSW5
GALVO PARK POSITION
S1
SW DIP-6
U18
27C256
GLVLUT.DAT
GO[0..11]
GO[0..12]
U23
74ALS574
CLK
OC
U19
DAC7545
VREF
RFBK
IOUT1
IOUT2
GND
CONNECT DGND AND EGND HERE ONLY.
-10VREF
GLV OFF
R58 25K
R79 10.0K
R80 10.0K
U20D
AD704
R81 15.0K
GLV SPAN
R59 25K
R95 10.0K
U20B
AD704
R97 15.0K
GLVOUT
TP6
J1
GALVO
MLX2
C88 10 uF 60V
C89 10 uF 60V
C55 .1 uF
C56 .1 uF
U20A
AD704
R117 47.5
R118 47.5
-15VB
+15VB
D14 1N4148
R123 1.00K
(NOT LS20)
VCC
R77 499
CLK24
-RES2
-GLVENB
-NXTSCN
(LS20: SSCANCK)
U32
EPF8282TC100
DCFMGV.GDF
/RESET
/NXTSCN
/GLVENB
/CTR
/PKSW0
/PKSW1
/PKSW2
/PKSW3
/PKSW4
/PKSW5
GUPCLK
LBCNT
/DASTRB
ENCAOUT
FILMCNT0
FILMCNT8
FCNT[0..8]
-PKSW[0..5]
(LS20 ONLY)
R132
R133
R134 1.00K
R135 1.00K
Q5 2N2222
Q6 2N2222
LDENB
-LDPWR
LASER DIODE DRIVER
J11
LSR DIO
2X5
+15VBIN
-15VBIN
AUX PWR
J10
MLX 2X3
D13 1N4001
D12 1N4001
L4 1 uH
L5 1 uH
C45 22 uF 25V
C44 22 uF 25V
C43 .1 uF
C42 .1 uF
FILM ENC
J9
2X5
R94 100K
ENCAOUT
-MTRENF
-FILMCKF
-FILMRVF
ZCLK
-CONFIG0
SER
RP2
SIP 7X4.7K
U10D
AD704
-6VA
R42 10.0K
R83 10.0K
U24
DAC7545
R38 154
C22 33 pF
C23 .1 uF
C24 .1 uF
U10A
AD704
R36 20.0K
R35 4.99K
R37 10.0K
C3 .01 uF
U10B
AD704
C2 22 uF 25V
C10 22 uF 25V
R33 499
R34 10.0K
U10C
AD704
R8 22.1K
R7 5. 6W
Q2 MJE200
Q3 MJE210
C33 22 uF 25V
C34 .1 uF
C46 22 uF 25V
C47 .1 uF
R95 4.99K
TP5
FILM MTR
1X5
K1
SS DC RELAY
U9B
7406
-SCAN
-MTRENB
FILMCLK
-FILMREV
R114 100
R115 100
R116 100
C64 100 pF
C65 100 pF
C66 100 pF
-MTRENF
FILMCKF
-FILMRVF
= DIGITAL GND
= ANALOG GND
= AUX GND

ISSUED:		LUMISYS, INC. 225 HUMBOLDT COURT SUNNYVALE, CA 94089
CHECKED		
DRAWN: ART LIM	06/18/98	
APPROVALS	DATE	

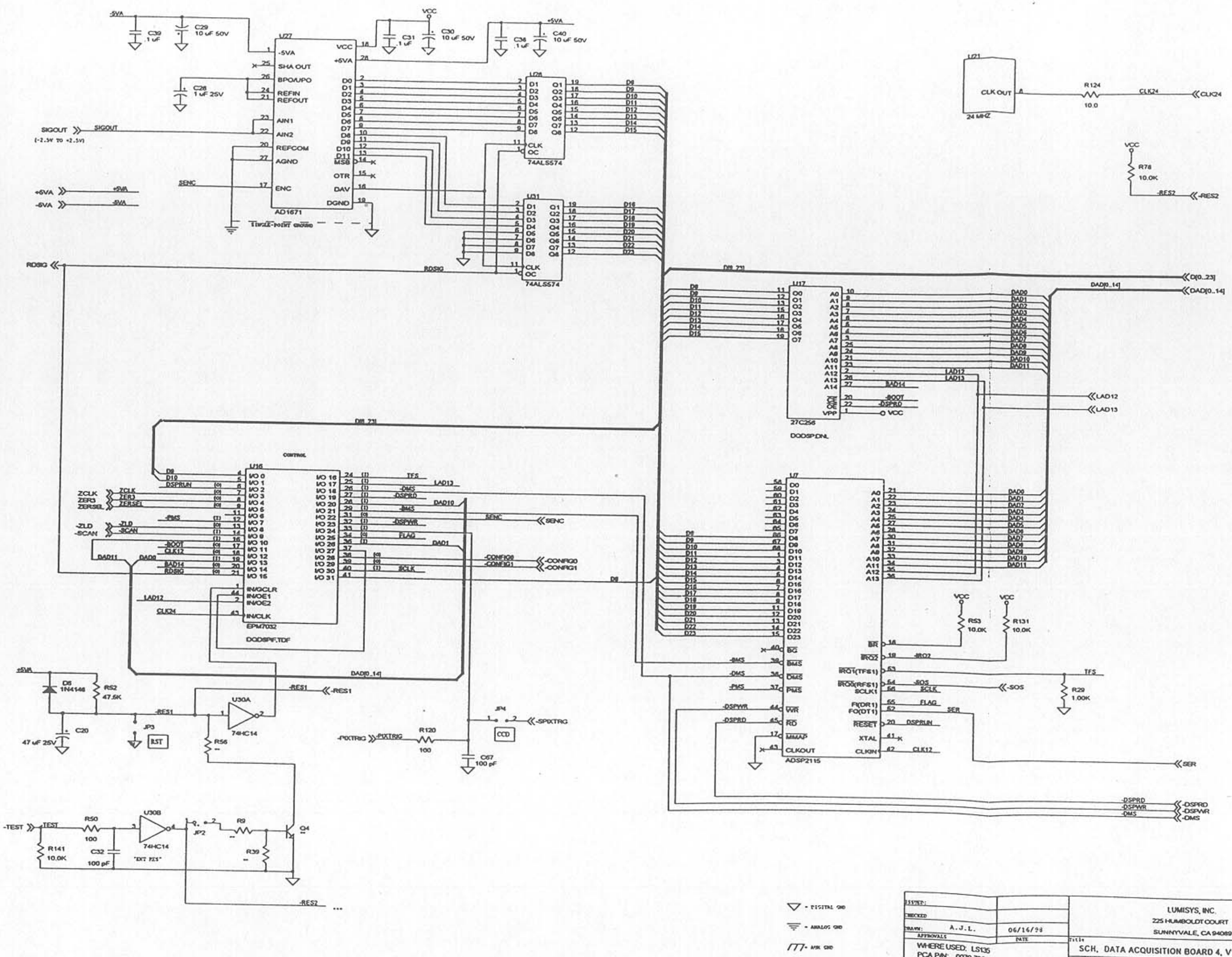
WHERE USED: LS135
PCA P/N: 0070-735
PCB P/N: 0069-702
ORCAD FILE: D4135CR4.SCH

Title
SCH, DATA ACQUISITION BOARD 4, V1, LS135

Size C
Document Number 0070-476 -
Rev 02
Date: Tuesday, June 16, 1998
Sheet 4 of 4


DCB
TO DCB
J2
2X20
-PIXTRIG
FILMCLK
SCANCLK
SPARE1
SPARE2
-FILMREV
-ISFILM
-SCAN
-MTRENB
-SOS
-EVENT0
-EVENT1
-DATAVAIL
SPARE3
-TEST
REGSEL0
REGSEL1
-DACORD
-DACOWR
DBSA0
TP7
PIXTRIG
RP5
RP6
330/470
-RES1
FILMFEED
U30C
74HC14
R121
1.00K
U14
TR
CV
THR
DIS
Q
C21
.01 uF
C9
.1 uF
R31
10.0K
R54
R55
VCC
FDUR
+15VBIN
F2
1A SB
+15FUSED
D7
R57
499
Q1
-FEED
SW
TO EXTERNAL SWITCHES
FILM FEED
J5
1X6
FF
TP12
-XOVER
-RAMRD
VCC2
RP4
SIP 7X4.7K
U9A
7406
D9
1N4146
D10
1N4146
F1
FLTR3TERM
VCCD
R6
47.5
R32
47.5
IND
TO INDICATOR BOARD
J6
1X5
-SCANLED
R4
100K
R5
10.0K
R30
10.0K
-EVENT0
-EVNT0
-EVNT1
C1
.1 uF
C8
.1 uF
D8
D11
D15
D16
ISFILM
SCANOK
LDENB
LDPWR
U29
EPF8452QC160
CLK24
-DMS
-DSPRD
-DSPWR
FILMDET
SENC
R119
100
C52
.001 uF
R101
100
C57
.001 uF
DAD[0..14]
LAD12
LAD13
-RES2
ZCLK
-CONFIG1
SER
RP3
SIP 7X4.7K
RDSIG
-MTRENB
J14
1X6
AUX I/O
AUXIN
AUXOUT
AUXVOUT
U8
74ALS245
U34
U35
74ALS990
SOS
TP8
J13
2X10
LED CTRL
(LS20 ONLY)
U27
U13
32KX8RAM
CAL TABLE, LUTS
D[0..23]
DD[0..7]
** = NOT INSTALLED
= DIGITAL GND
= ANALOG GND
= AUX GND

ISSUED:		LUMISYS, INC. 225 HUMBOLDT COURT SUNNYVALE, CA 94089
CHECKED		
DRAWN: A.J.L.	06/16/98	
APPROVALS	DATE	Title SCH, DATA ACQUISITION BOARD 4, V1, LS135
WHERE USED: LS135 PCA P/N: 0070-735 PCB P/N: 0069-702 ORCAD FILE: D4135CR3.SCH		Size C · Document Number 0070-476 · Rev 02
		Date: Tuesday, June 16, 1998 · Sheet 3 of 4


U27
AD1671
-5VA
SHA OUT
BPO/UPO
REFIN
REFOUT
AIN1
AIN2
REFCOM
AGND
ENC
VCC
+5VA
D0
D1
D2
D3
D4
D5
D6
D7
D8
D9
D10
D11
MSB
OTR
DAV
DGND
SINGLE-POINT GROUND
SIGOUT
(-2.5V TO +2.5V)
SENC
+5VA
-5VA
C39 .1 uF
C29 10 uF 50V
C28 1 uF 25V
C31 .1 uF
C30 10 uF 50V
C38 .1 uF
C40 10 uF 50V
VCC
U28
U31
74ALS574
CLK
OC
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
D8
D9
D10
D11
D12
D13
D14
D15
D16
D17
D18
D19
D20
D21
D22
D23
RDSIG
D[8..23]
D[0..23]
DAD[0..14]
U21
CLK OUT
24 MHZ
R124
10.0
CLK24
R78
10.0K
-RES2
U17
27C256
DODSP.DNL
O0
O1
O2
O3
O4
O5
O6
O7
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
A14
CE
OE
VPP
DAD0
DAD1
DAD2
DAD3
DAD4
DAD5
DAD6
DAD7
DAD8
DAD9
DAD10
DAD11
LAD12
LAD13
BAD14
-BOOT
-DSPRD
U16
CONTROL
EPM7032
DODSPIF.TDF
I/O 0
I/O 1
I/O 2
I/O 3
I/O 4
I/O 5
I/O 6
I/O 7
I/O 8
I/O 9
I/O 10
I/O 11
I/O 12
I/O 13
I/O 14
I/O 15
I/O 16
I/O 17
I/O 18
I/O 19
I/O 20
I/O 21
I/O 22
I/O 23
I/O 24
I/O 25
I/O 26
I/O 27
I/O 28
I/O 29
I/O 30
I/O 31
IN/OCLR
IN/OE1
IN/OE2
IN/CLK
DSPRUN
ZCLK
ZER3
ZERSEL
-PMS
-ZLD
-SCAN
-BOOT
CLK12
BAD14
RDSIG
DAD11
DAD0
LAD12
CLK24
TFS
LAD13
-DMS
-DSPRD
DAD10
-BMS
-DSPWR
FLAG
DAD1
SCLK
SENC
-CONFIG0
-CONFIG1
DAD[0..14]
U7
ADSP2115
BG
BMS
DMS
PMS
WR
RD
MMAP
CLKOUT
BR
IRQ2
IRQ1(TFS1)
IRQ0(RFS1)
SCLK1
FI(DR1)
FO(DT1)
RESET
XTAL
CLKIN
-IRQ2
-SOS
SER
R53 10.0K
R131 10.0K
R29 1.00K
-DSPRD
-DSPWR
-DMS
D6
1N4148
R52 47.5K
C20 47 uF 25V
-RES1
JP3
RST
U30A
74HC14
R56
JP4
CCD
-SPIXTRG
-PIXTRIG
R120 100
C67 100 pF
-TEST
TEST
R141 10.0K
R50 100
C32 100 pF
U30B
74HC14
"EXT TES"
JP2
R9
R39
Q4
-RES2 ...
= DIGITAL GND
= ANALOG GND
= ANK GND

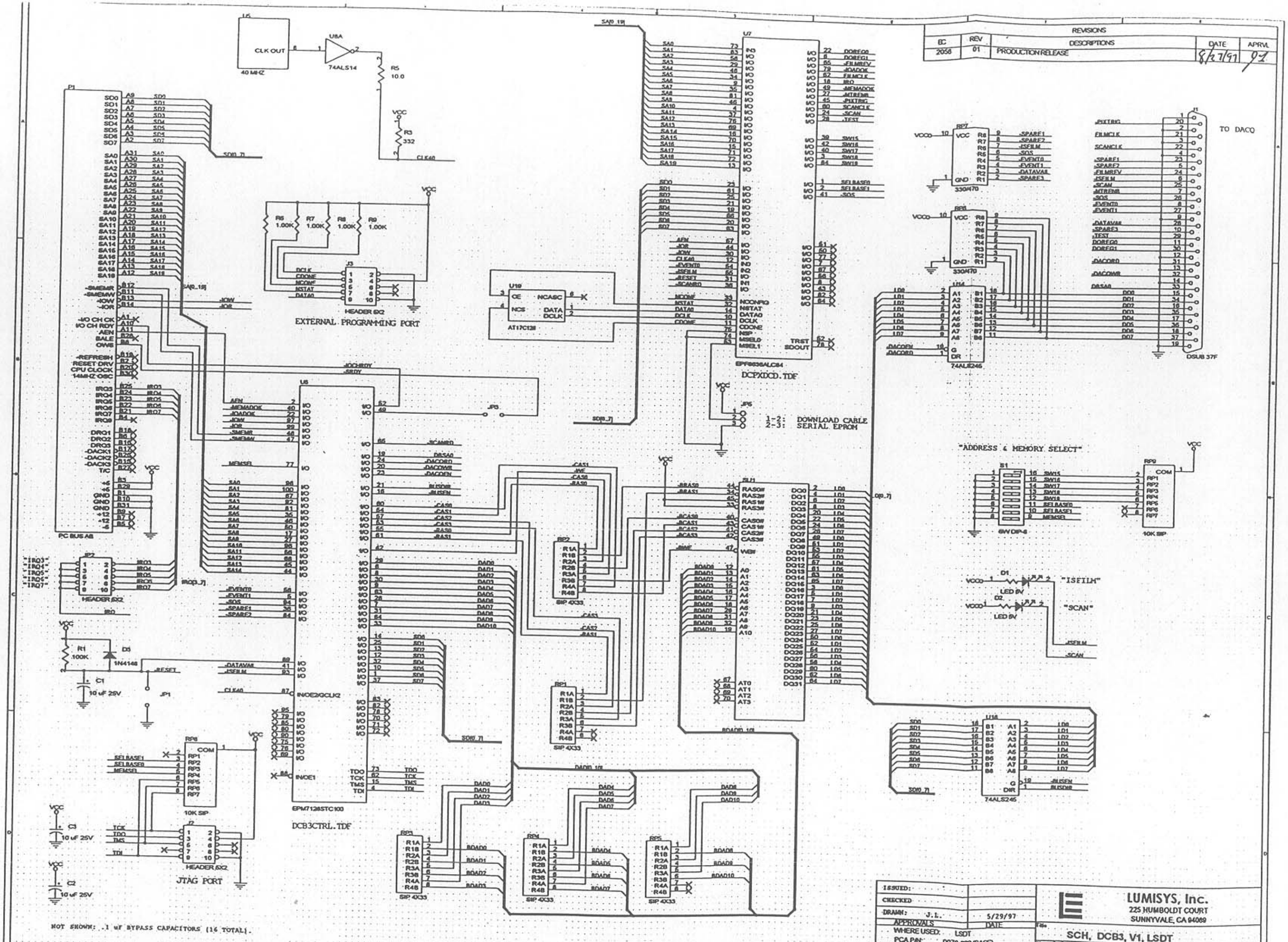
ISSUED:
CHECKED
DRAWN: A.J.L. 06/16/98
APPROVALS DATE

WHERE USED: LS135
PCA P/N: 0070-735
PCB P/N: 0069-702
ORCAD FILE: D4135CR2.SCH

LUMISYS, INC.
225 HUMBOLDT COURT
SUNNYVALE, CA 94089

Title		
SCH, DATA ACQUISITION BOARD 4, V1, LS135		
Size: C	Document Number: 0070-476	Rev: 02
Date: Tuesday, June 16, 1998	Sheet 2 of 4	

REVISIONS				
EC	REV	DESCRIPTIONS	DATE	APRVL
2058	01	PRODUCTION RELEASE	8/27/97	97

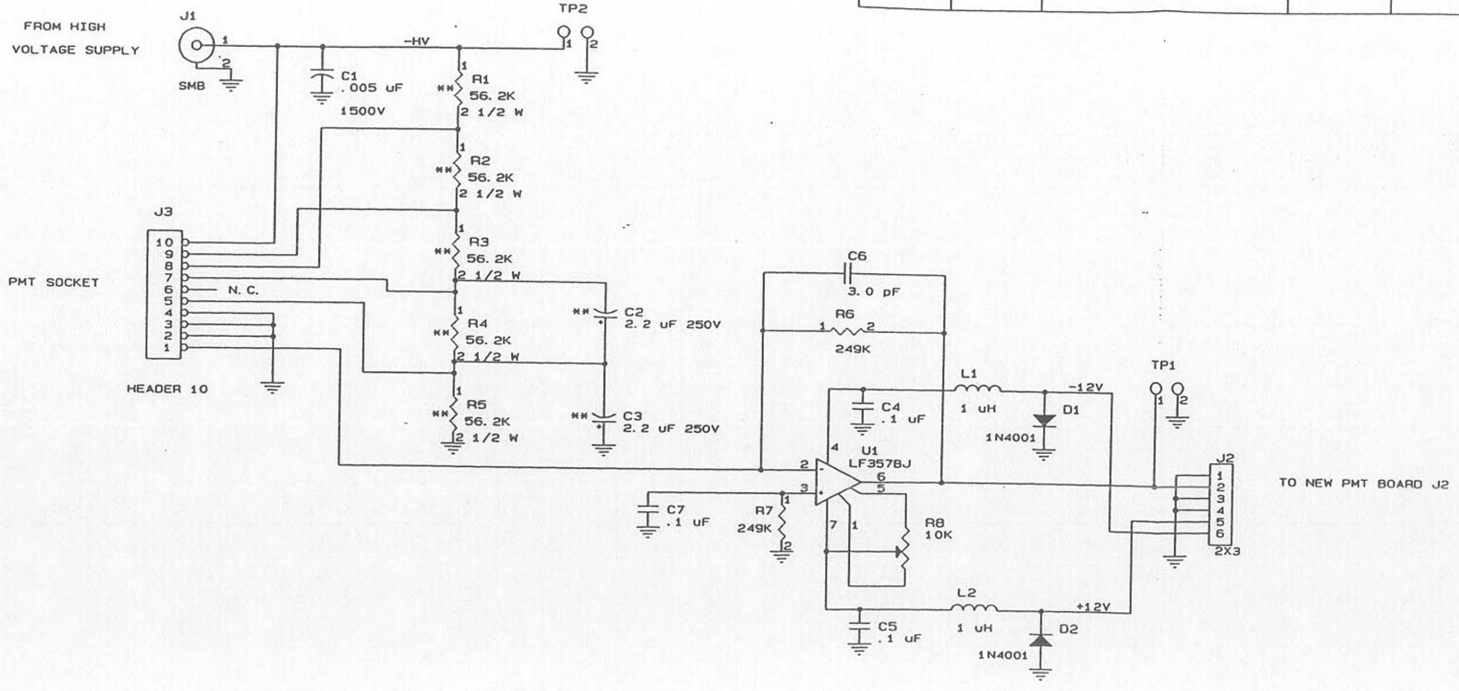

U5
CLK OUT
40 MHZ
U8A
74ALS14
R5
10.0
R3
332
CLK40
P1
PC BUS A8
SD[0..7]
SA[0..19]
R6 1.00K
R7 1.00K
R8 1.00K
R9 1.00K
J3
HEADER 5X2
EXTERNAL PROGRAMMING PORT
U19
AT17C128
OE
NCASC
NCS
DATA
DCLK
U7
EPF8636ALC84
DCPXDCD.TDF
JP5
1-2: DOWNLOAD CABLE
2-3: SERIAL EPROM
U8
EPM7128STC100
DCB3CTRL.TDF
JP3
JP1
R1
100K
D5
1N4148
C1
10 uF 25V
-RESET
JP2
HEADER 5X2
IRQ[3..7]
RP8
10K SIP
J2
HEADER 5X2
JTAG PORT
C3
10 uF 25V
C2
10 uF 25V
RP2
RP1
RP3
RP4
RP5
SIP 4X33
SU1
D[0..7]
BOAD[0..10]
DAD[0..10]
RP7
330/470
RP6
330/470
U14
74ALS245
J1
DSUB 37F
TO DACQ
"ADDRESS & MEMORY SELECT"
S1
8W DIP-8
RP9
10K SIP
D1
LED 5V
"ISFILM"
D2
LED 5V
"SCAN"
U18
74ALS245

NOT SHOWN: .1 uF BYPASS CAPACITORS (16 TOTAL).

ISSUED:		**LUMISYS, Inc.** 225 HUMBOLDT COURT SUNNYVALE, CA 94089	
CHECKED			
DRAWN: J.L.	5/29/97		
APPROVALS	DATE	Title SCH, DCB3, V1, LSDT	
WHERE USED: LSDT PCA P/N: 0070-232 (BASE) PCB P/N: 0070-235 ORCAD FILE: DCB3.DSN		Size C Document Number 0070-236	Rev 01
		Date: AUG 19, 1997	Sheet 1 of 1

REVISIONS

EC NO.	REV	DESCRIPTION	DATE	APPROVAL
1279	01	PRODUCTION RELEASE	06/13/95	E. M.
1382	02	ADD ** NOT USED ON LSCR.	2-5-96	Em.


FROM HIGH VOLTAGE SUPPLY
J1
SMB
1
2
-HV
C1
.005 uF
1500V
TP2
1
2
R1
56. 2K
1/2 W
R2
56. 2K
1/2 W
R3
56. 2K
1/2 W
R4
56. 2K
1/2 W
R5
56. 2K
1/2 W
**
J3
PMT SOCKET
10
9
8
7
6
5
4
3
2
1
N. C.
HEADER 10
C2
2. 2 uF 250V
C3
2. 2 uF 250V
C6
3. 0 pF
R6
249K
U1
LF357BJ
C4
.1 uF
L1
1 uH
-12V
D1
1N4001
C7
.1 uF
R7
249K
R8
10K
C5
.1 uF
L2
1 uH
+12V
D2
1N4001
TP1
J2
2X3
TO NEW PMT BOARD J2

** NOT USED ON LSCR

ISSUED:
CHECKED
DRAWN: EM 5/25/95
APPROVALS DATE
WHERE USED: LUMISCAN LSDT

PCA P/N: 0069-195
PCB P/N: 0069-196
ORCAD FILE: PMTPA3R2. SCH

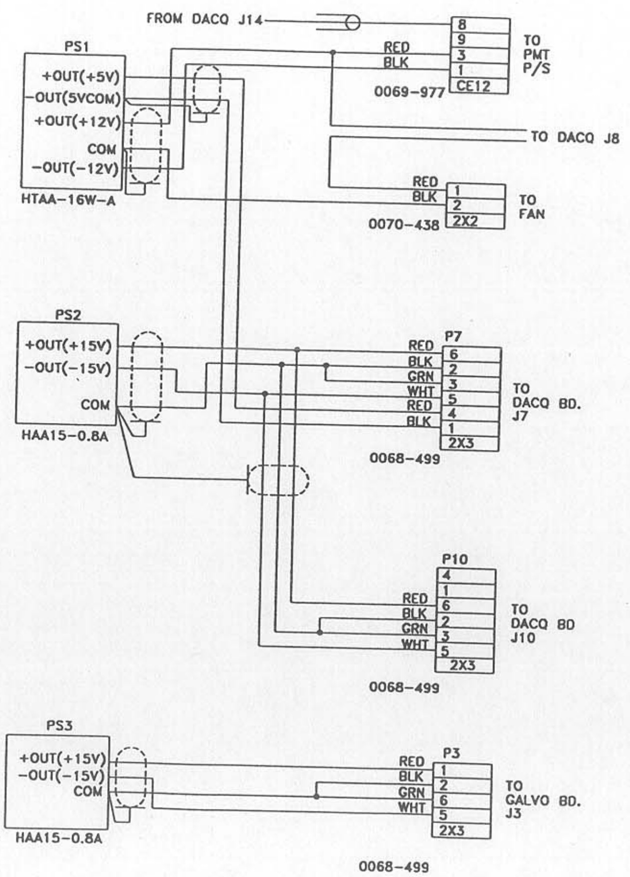
LUMISYS, INC.
225 HUMBOLDT COURT
SUNNYVALE, CA 94089

Title		
SCH. PMT PREAMP, V3, LSDT		
Size	Document Number	REV
B	0069-197	02
Date: January 30, 1996	Sheet 1 of 1	

THIS DOCUMENT CONTAINS PROPRIETARY INFORMATION OF LUMISYS, INC. AND IS TENDERED SUBJECT TO THE CONDITIONS THAT THE INFORMATION (A) BE RETAINED IN CONFIDENCE (B) NOT BE USED OR INCORPORATED IN ANY PRODUCT EXCEPT UNDER AN EXPRESS WRITTEN AGREEMENT WITH LUMISYS, INC.

REVISIONS

ECN	REV	DESCRIPTION	CHG BY	DATE	APPROVED
		SEE SHEET ONE			

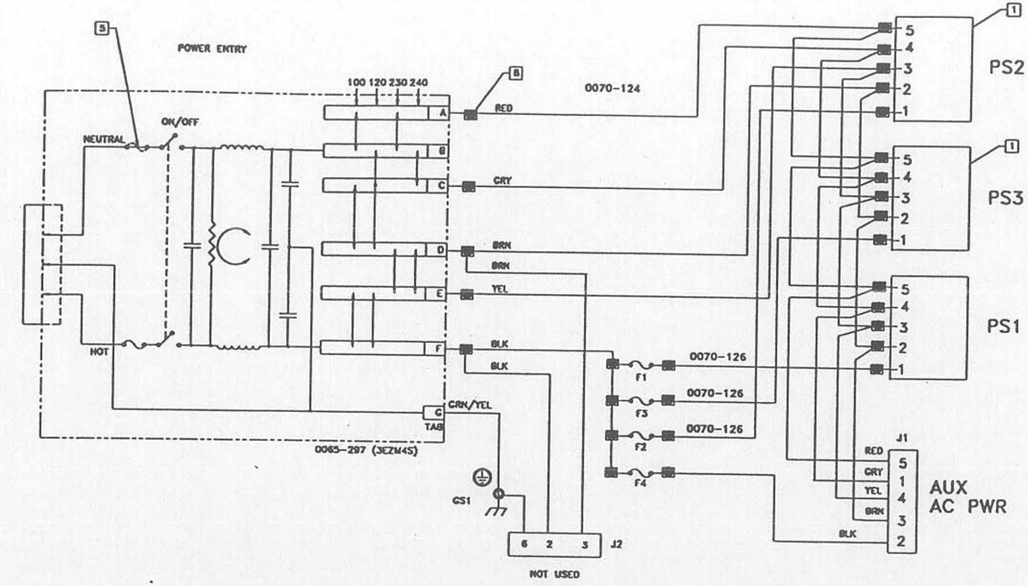

FROM DACQ J14
PS1
+OUT(+5V)
-OUT(5VCOM)
+OUT(+12V)
COM
-OUT(-12V)
HTAA-16W-A
RED
BLK
8
9
3
1
CE12
0069-977
TO PMT P/S
TO DACQ J8
RED
BLK
1
2
2X2
0070-438
TO FAN
PS2
+OUT(+15V)
-OUT(-15V)
COM
HAA15-0.8A
P7
RED
BLK
GRN
WHT
RED
BLK
6
2
3
5
4
1
2X3
0068-499
TO DACQ BD. J7
P10
RED
BLK
GRN
WHT
4
1
6
2
3
5
2X3
0068-499
TO DACQ BD J10
PS3
+OUT(+15V)
-OUT(-15V)
COM
HAA15-0.8A
P3
RED
BLK
GRN
WHT
1
2
6
5
2X3
0068-499
TO GALVO BD. J3

MATERIAL N/A	DRAWN BY S. CLOER	DATE 09/28/98	LUMISYS INC. Sunnyvale, CA
FINISH N/A	DESIGNED BY A. LIM	DATE 09/16/98	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: DECIMALS .XX ±.01 .XXX ±.005 ANGLES ± 1° INTERPERT DIM AND TOL PER ASME Y14.5M - 1994	CHECKED BY	DATE	TITLE DIAG, AC & DC WIRING, LS135
	ENGR APPROVAL	DATE	
THIRD ANGLE PROJECTION	INITIAL APPLICATION		SIZE B · DWG NO. 0071-317 · REV 01
	SCALE: NTS (DO NOT SCALE)		ACAD FILE: 71-31721.DWG · SHEET 2 OF 2

THIS DOCUMENT CONTAINS PROPRIETARY INFORMATION OF LUMISYS, INC. AND IS TENDERED SUBJECT TO THE CONDITIONS THAT THE INFORMATION (A) BE RETAINED IN CONFIDENCE (B) NOT BE USED OR INCORPORATED IN ANY PRODUCT EXCEPT UNDER AN EXPRESS WRITTEN AGREEMENT WITH LUMISYS, INC.

REVISIONS

ECN	REV	DESCRIPTION	CHG BY	DATE	APPROVED
2311	01	PRODUCTION RELEASE	SEC	09/28/98	AL


POWER ENTRY
5
100 120 230 240
ON/OFF
NEUTRAL
HOT
A
B
C
D
E
F
G
TAB
0065-297 (3EZM4S)
B
RED
GRY
BRN
BRN
YEL
BLK
BLK
GRN/YEL
GS1
J2
6 2 3
NOT USED
0070-124
0070-126
0070-126
0070-126
F1
F3
F2
F4
1
PS2
1
PS3
PS1
5 4 3 2 1
5 4 3 2 1
5 4 3 2 1
J1
RED
GRY
YEL
BRN
BLK
5 1 4 3 2
AUX
AC PWR

NOTES:

1. CUT JUMPERS VW1 AND VW2 FOR ±15V, ON PS2 AND PS3.

2. CUT JUMPERS ON TRANSFORMER PRIMARY SIDE OF PS1, PS2 PS3 AND PS5.

3. ALL WIRES 20 AWG.

4. INTERNAL FUSES F1, F2, F3 AND F4 ARE .315A, 250V

5. PROVISION FOR DUAL EUROPEAN FUSING ON INPUT POWER FUSES:

©100/120 VAC	©230/240VAC
1.5A-SB, 250V	1.0A-SB, 250V

6. ● DENOTES QUICK DISCONNECT TERMINALS

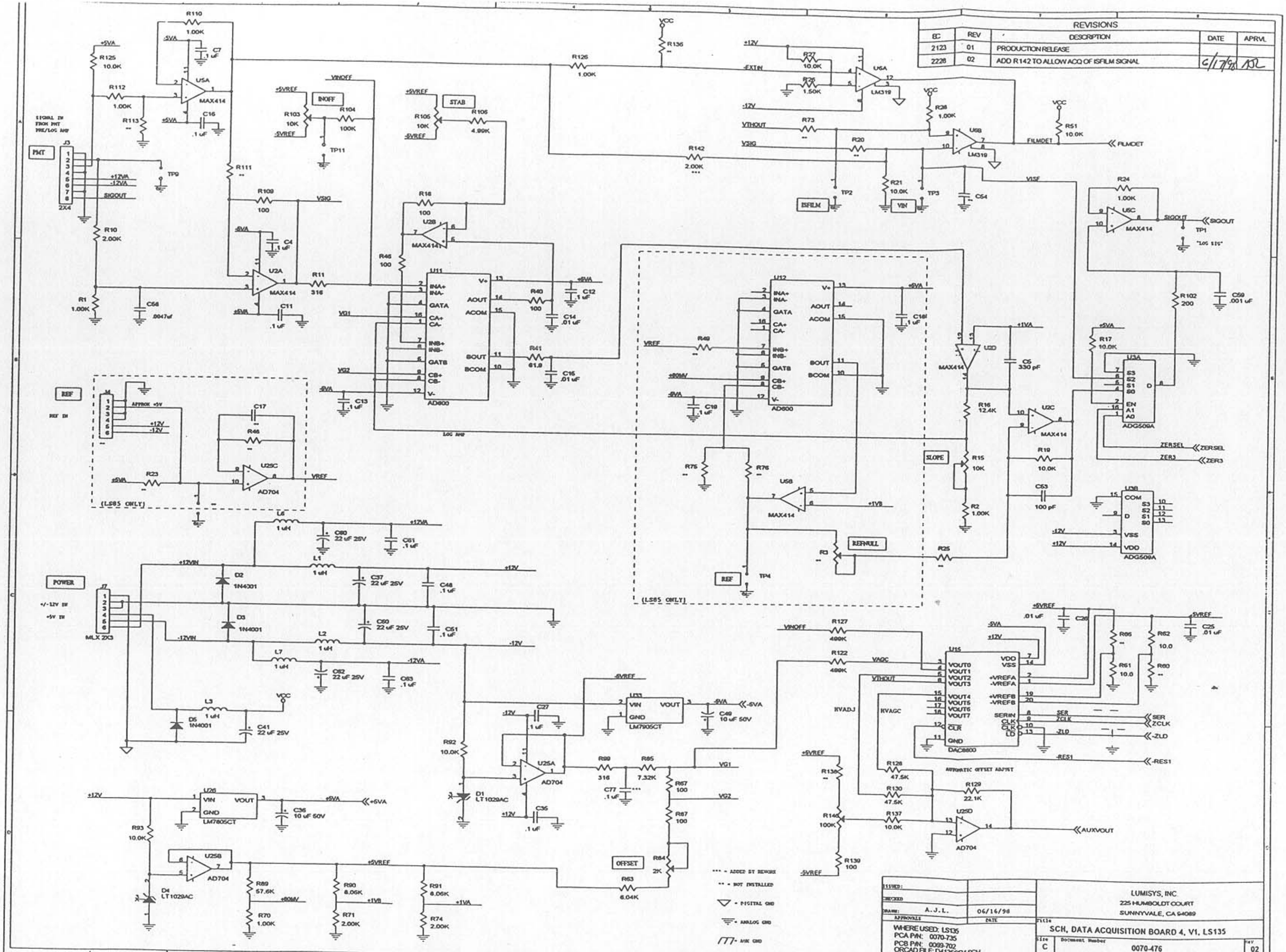
OCT 1 4 1998

WIRE LIST

FROM	TO	TO	TO	TO	COLOR	REMARKS
CORC-A	PS2-5	PS3-5	PS1-5	J1-5	RED	0070-124
CORC-B						"
CORC-C	PS2-4	PS3-4	PS1-4	J1-1	GRY	"
CORC-D	PS1-2	PS3-2	PS2-2	J1-3	BRN	"
CORC-D	J2-3				BRN	"
CORC-E	PS2-3	PS3-3	PS1-3	J1-4	YEL	"
CORC-F	F1	F3	F2	F5	BLK	"
CORC-F	J2-2				BLK	"
CORC-GND	GS-1				GRN/YEL	
J2-4	GS-1				GRN/YEL	
F2	PS2-1				BLK	0070-126
F3	PS3-1				BLK	"
F1	PS1-1				BLK	"
F4	J1-2				BLK	

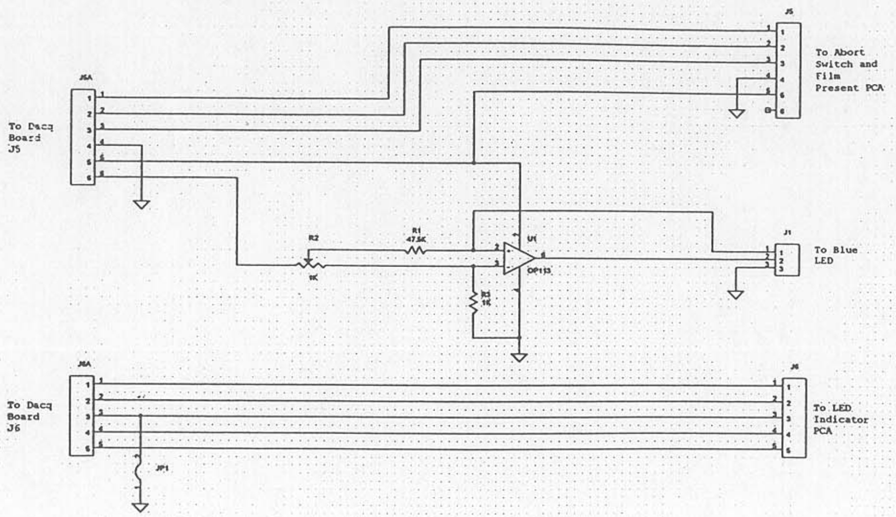
MATERIAL	DRAWN BY S.CLOER	DATE 09/28/98	LUMISYS INC. Sunnyvale, CA
FINISH	DESIGNED BY A. LIM	DATE 09/16/98	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: DECIMALS .XX ±.01 .XXX ±.005 ANGLES ± 1° INTERPERT DIM AND TOL PER ASME Y14.5M – 1994	CHECKED BY	DATE	TITLE DIAG, AC & DC WIRING, LS135
THIRD ANGLE PROJECTION	ENGR APPROVAL AL	DATE 10-13-98	SIZE B · DWG NO. 0071-317 · REV 01
	INITIAL APPLICATION		
	SCALE: NTS (DO NOT SCALE)		ACAD FILE: 71-31711.DWG · SHEET 1 OF 2

REVISIONS				
EC	REV	DESCRIPTION	DATE	APRVL
2123	01	PRODUCTION RELEASE		
2226	02	ADD R142 TO ALLOW ACQ OF ISFILM SIGNAL	6/17/98	ADL


SIGNAL IN FROM PMT PRE/LOG AMP
PMT
J3
2X4
+12VA
-12VA
SIGOUT
TP9
R125 10.0K
R112 1.00K
R113 **
R110 1.00K
C7 .1 uF
U5A MAX414
C16 .1 uF
+5VA
-5VA
R10 2.00K
R1 1.00K
C56 .0047uf
R111 **
R109 100
VSIG
C4 .1 uF
U2A MAX414
C11 .1 uF
R11 316
VINOFF
+5VREF
-5VREF
INOFF
R103 10K
R104 100K
TP11
STAB
R105 10K
R106 4.99K
R18 100
U2B MAX414
R46 100
U11 AD600
INA+
INA-
GATA
CA+
CA-
INB+
INB-
GATB
CB+
CB-
V+
V-
AOUT
ACOM
BOUT
BCOM
VG1
VG2
R40 100
C12 .1 uF
C14 .01 uF
R41 61.9
C15 .01 uF
C13 .1 uF
LOG AMP
R126 1.00K
VCC
R136 **
+12V
-EXTIN
R27 10.0K
R26 1.50K
U6A LM319
-12V
VTHOUT
R73 **
R142 2.00K ***
R20 **
R21 10.0K
TP2
TP3
ISFILM
VIN
C54
R38 1.00K
U6B LM319
FILMDET
R51 10.0K
FILMDET
VISF
R24 1.00K
U5C MAX414
SIGOUT
TP1
"LOG SIG"
R102 200
C59 .001 uF
U12 AD600
VREF
R49 **
+60MV
C18 .1 uF
C19 .1 uF
R75 **
R76 **
U5B MAX414
+1VB
R3 **
REFNULL
REF
TP4
(LS85 ONLY)
U2D MAX414
+1VA
C5 330 pF
R16 12.4K
U2C MAX414
R19 10.0K
C53 100 pF
SLOPE
R15 10K
R2 1.00K
R25 **
R17 10.0K
U3A ADG509A
S3 S2 S1 S0 EN A1 A0 D
ZERSEL
ZER3
U3B ADG509A
COM VSS VDD
REF
REF IN
J4
APPROX +5V
C17 **
R48 **
R23 **
U25C AD704
VREF
(LS85 ONLY)
POWER
J7
MLX 2X3
+/-12V IN
+5V IN
+12VIN
-12VIN
L6 1 uH
C80 22 uF 25V
C61 .1 uF
+12VA
D2 1N4001
L1 1 uH
C37 22 uF 25V
C48 .1 uF
D3 1N4001
C50 22 uF 25V
C51 .1 uF
L2 1 uH
L7 1 uH
C82 22 uF 25V
C83 .1 uF
-12VA
L3 1 uH
D5 1N4001
C41 22 uF 25V
-5VREF
U33 LM7905CT
VIN VOUT GND
C49 10 uF 50V
-5VA
C27 .1 uF
U25A AD704
C35 .1 uF
R92 10.0K
D1 LT1029AC
R99 316
R85 7.32K
C77 .1 uF ***
R67 100
R87 100
VG1
VG2
U26 LM7805CT
C36 10 uF 50V
+5VA
R93 10.0K
U25B AD704
D4 LT1029AC
R89 57.6K
R70 1.00K
+60MV
R90 8.06K
R71 2.00K
+1VB
R91 8.06K
R74 2.00K
+1VA
OFFSET
R84 2K
R63 6.04K
*** = ADDED BY REWORK
** = NOT INSTALLED
= DIGITAL GND
= ANALOG GND
= AUX GND
R127 499K
R122 499K
VAGC
VTHOUT
RVADJ
RVAGC
U15 DAC8800
VOUT0 VOUT1 VOUT2 VOUT3 VOUT4 VOUT5 VOUT6 VOUT7
VDD VSS
+VREFA -VREFA +VREFB -VREFB
SERIN CLK CLK LD CLR GND
SER
ZCLK
-ZLD
-RES1
C26 .01 uF
C25 .01 uF
R86
R62 10.0
R61 10.0
R60
AUTOMATIC OFFSET ADJUST
R128 47.5K
R130 47.5K
R129 22.1K
R137 10.0K
R138 **
R140 100K
R139 100
U25D AD704
AUXVOUT

ISSUED:		LUMISYS, INC. 225 HUMBOLDT COURT SUNNYVALE, CA 94089	
CHECKED			
DRAWN: A.J.L.	06/16/98		
APPROVALS	DATE	Title SCH, DATA ACQUISITION BOARD 4, V1, LS135	
WHERE USED: LS135 PCA P/N: 0070-735 PCB P/N: 0069-702 ORCAD FILE: D4135CR1.SCH		Size C — Document Number 0070-476	Rev 02
		Date: Tuesday, June 16, 1998	Sheet: 1 of 4

REVISIONS				
EC	REV	DESCRIPTION	DATE	APRVL
2157	A	PRE-PRODUCTION RELEASE	2/4/98	


J5A
To Dacq
Board
J5
J5
To Abort
Switch and
Film
Present PCA
R2
1K
R1
47.5K
R3
1K
U1
OP113
J1
To Blue
LED
J6A
To Dacq
Board
J6
JP1
J6
To LED
Indicator
PCA

ISSUED:	
CHECKED	
DRAWN: JCADOTTE	1/20/98
APPROVALS	DATE

WHERE USED: LS114/LS135
PCA P/N: 0070-677
PCB P/N: 0070-678
ORCAD FILE: LEDADPT2.DSN

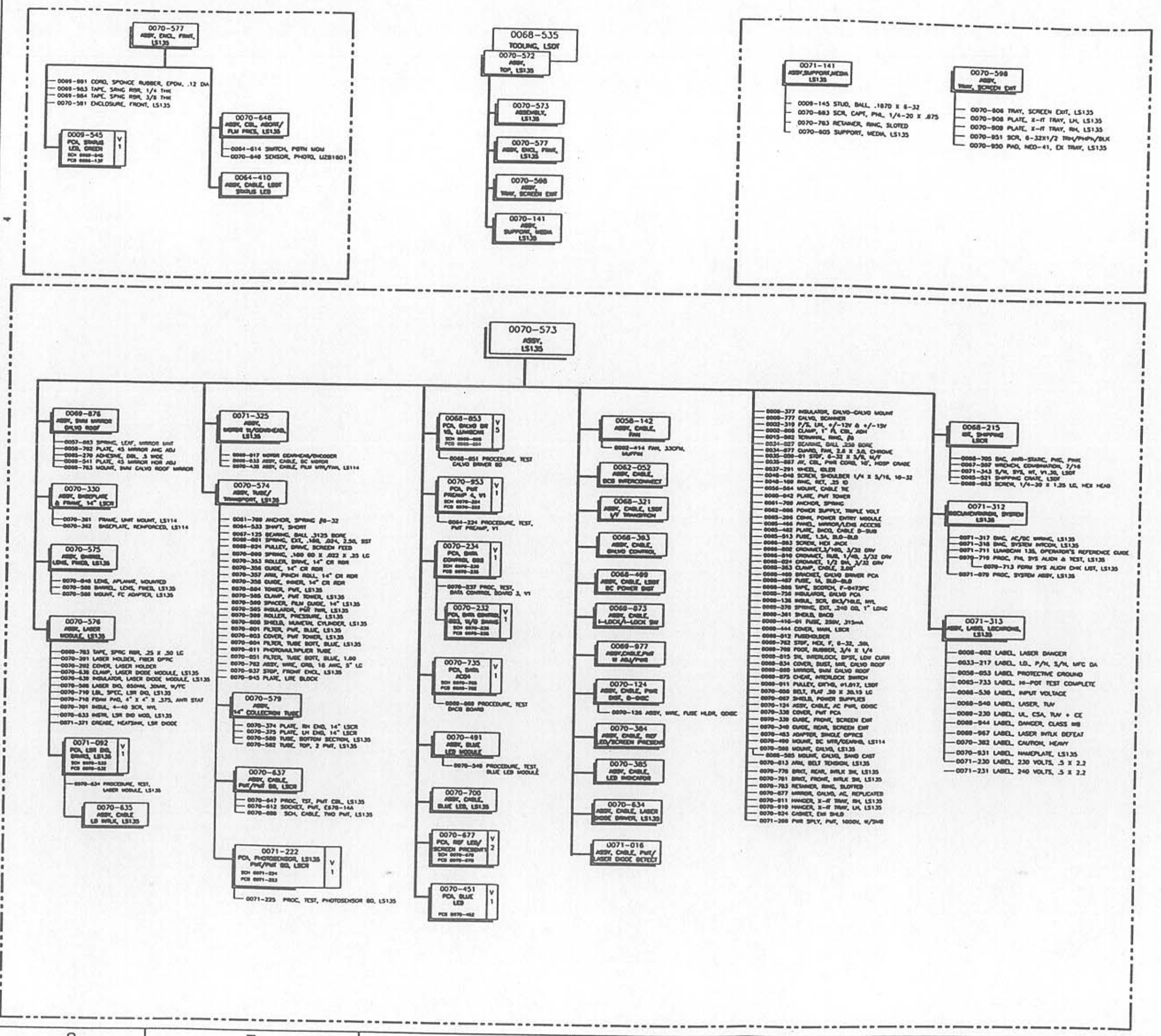
LUMISYS, Inc.
225 HUMBOLDT COURT
SUNNYVALE, CA 94089

Title
SCH, REF LED, SCRN PRES1, V2

Size	Document Number	Rev
C	0070-679	A

Date: Sheet 1 of 1

THIS DOCUMENT CONTAINS PROPRIETARY INFORMATION OF LUMISYS, INC. AND IS TENDERED SUBJECT TO THE CONDITIONS THAT THE INFORMATION (A) BE RETAINED IN CONFIDENCE (B) NOT BE USED OR INCORPORATED IN ANY PRODUCT EXCEPT UNDER AN EXPRESS WRITTEN AGREEMENT WITH LUMISYS, INC.


0070-577
ASSY, ENCL, FRNT, LS135
0009-891 CORD, SPONGE RUBBER, EPDM, .12 DIA
0069-983 TAPE, SPNG RBR, 1/4 THK
0069-984 TAPE, SPNG RBR, 3/8 THK
0070-581 ENCLOSURE, FRONT, LS135
0009-545
PCA, STATUS LED, GREEN
SCH 0069-546
PCB 0066-137
V 1
0070-648
ASSY, CBL, ABORT/ FLM PRES, LS135
0064-614 SWITCH, PBTN MOM
0070-849 SENSOR, PHOTO, UZB1601
0064-410
ASSY, CABLE, LSDT STATUS LED
0068-535
TOOLING, LSDT
0070-572
ASSY, TOP, LS135
0070-573
ASSEMBLY, LS135
0070-577
ASSY, ENCL, FRNT, LS135
0070-598
ASSY, TRAY, SCREEN EXIT
0070-141
ASSY, SUPPORT, MEDIA LS135
0071-141
ASSY,SUPPORT,MEDIA LS135
0009-145 STUD, BALL, .1870 X 6-32
0070-683 SCR, CAPT, PNL, 1/4-20 X .875
0070-783 RETAINER, RING, SLOTED
0070-805 SUPPORT, MEDIA, LS135
0070-598
ASSY, TRAY, SCREEN EXIT
0070-806 TRAY, SCREEN EXIT, LS135
0070-908 PLATE, X-IT TRAY, LH, LS135
0070-909 PLATE, X-IT TRAY, RH, LS135
0070-951 SCR, 6-32X1/2 TRH/PHPh/BLK
0070-950 PAD, NEO-41, EX TRAY, LS135
0070-573
ASSY, LS135
0069-876
ASSY, SWM MIRROR GALVO ROOF
0057-683 SPRING, LEAF, MIRROR UNIT
0058-782 PLATE, 45 MIRROR ANG ADJ
0085-270 ADHESIVE, DBL, .5 WIDE
0088-541 PLATE, 45 MIRROR HOR ADJ
0088-783 MOUNT, SWM GALVO ROOF MIRROR
0070-330
ASSY, BASEPLATE & FRAME, 14" LSCR
0070-361 FRAME, UNIT MOUNT, LS114
0070-362 BASEPLATE, REINFORCED, LS114
0070-575
ASSY, BARREL, LENS, FIXED, LS135
0070-840 LENS, APLANAT, MOUNTED
0070-588 BARREL, LENS, FIXED, LS135
0070-589 MOUNT, FC ADAPTER, LS135
0070-576
ASSY, LASER MODULE, LS135
0089-783 TAPE, SPNG RBR, .25 X .50 LG
0070-391 LASER HOLDER, FIBER OPTIC
0070-392 COVER, LASER HOLDER
0070-638 CLAMP, LASER DIODE MODULE, LS135
0070-639 INSULATOR, LASER DIODE MODULE, LS135
0070-568 LASER DIO, 650NM, 30MW, W/FC
0070-719 LBL, SPEC, LSR DIO, LS135
0070-718 FOAM PAD, 4" X 4" X .375, ANTI STAT
0070-701 INSUL, 4-40 SCR, NYL
0070-633 INSTR, LSR DIO MOD, LS135
0071-371 GREASE, HEATSINK, LSR DIODE
0071-092
PCA, LSR DIO, DRVRS, LS135
SCH 0070-533
PCB 0070-532
V 1
0070-634 PROCEDURE, TEST, LASER MODULE, LS135
0070-635
ASSY, CABLE LD INTLK, LS135
0071-325
ASSY, MOTOR W/GEARHEAD, LS135
0088-917 MOTOR GEARHEAD/ENCODER
0088-833 ASSY, CABLE, DC MOTOR
0070-438 ASSY, CABLE, FLM MTR/FAN, LS114
0070-574
ASSY, TUBE/ TRANSPORT, LS135
0081-789 ANCHOR, SPRING #8-32
0064-533 SHAFT, SHORT
0067-125 BEARING, BALL .3125 BORE
0088-881 SPRING, EXT, .180, .024, 2.50, SST
0088-824 PULLEY, DRIVE, SCREEN FEED
0070-880 SPRING, .100 OD X .022 X .25 LG
0070-353 ROLLER, DRIVE, 14" CR RDR
0070-356 GUIDE, 14" CR RDR
0070-357 ARM, PINCH ROLL, 14" CR RDR
0070-358 GUIDE, INNER, 14" CR RDR
0070-584 TOWER, PMT, LS135
0070-585 CLAMP, PMT TOWER, LS135
0070-589 SPACER, FILM GUIDE, 14" LS135
0070-585 INSULATOR, PMT PWR, LS135
0070-588 ROLLER, PRESSURE, LS135
0070-800 SHIELD, MUMETAL CYLINDER, LS135
0070-801 FILTER, PMT, BLUE, LS135
0070-803 COVER, PMT TOWER, LS135
0070-804 FILTER, TUBE BOTT, BLUE, LS135
0070-811 PHOTOMULTIPLIER TUBE
0070-851 FILTER, TUBE BOTT, BLUE, 1.00
0070-762 ASSY, WIRE, GRD, 16 AWG, 5" LG
0070-937 STOP, FRONT ENCL, LS135
0070-945 PLATE, LITE BLOCK
0070-579
ASSY, 14" COLLECTION TUBE
0070-374 PLATE, RH END, 14" LSCR
0070-375 PLATE, LH END, 14" LSCR
0070-580 TUBE, BOTTOM SECTION, LS135
0070-582 TUBE, TOP, 2 PMT, LS135
0070-637
ASSY, CABLE, PMT/PMT BD, LSCR
0070-647 PROC, TST, PMT CBL, LS135
0070-612 SOCKET, PMT, E678-14A
0070-688 SCH, CABLE, TWO PMT, LS135
0071-222
PCA, PHOTOSENSOR, LS135 PMT/PMT BD, LSCR
SCH 0071-224
PCB 0071-223
V 1
0071-225 PROC, TEST, PHOTOSENSOR BD, LS135
0068-853
PCA, GALVO DR V5, LUMISCAN
SCH 0068-888
PCB 0088-224
V 5
0068-851 PROCEDURE, TEST GALVO DRIVER BD
0070-953
PCA, PMT PREAMP 4, V1
SCH 0070-254
PCB 0070-253
V 1
0064-224 PROCEDURE, TEST, PMT PREAMP, V1
0070-234
PCA, DATA CONTROL BD3
SCH 0070-236
PCB 0070-235
V 1
0070-237 PROC, TEST, DATA CONTROL BOARD 3, V1
0070-232
PCA, DATA CONTROL BD3, W/O SWMS
SCH 0070-236
PCB 0070-235
V 1
0070-735
PCA, DATA ACQ4
SCH 0070-700
PCB 0068-702
V 1
0068-869 PROCEDURE, TEST DACQ BOARD
0070-491
ASSY, BLUE LED MODULE
0070-549 PROCEDURE, TEST, BLUE LED MODULE
0070-700
ASSY, CABLE, BLUE LED, LS135
0070-677
PCA, REF LED/ SCREEN PRESENT
SCH 0070-678
PCB 0070-679
V 2
0070-451
PCA, BLUE LED
PCB 0070-452
V 1
0058-142
ASSY, CABLE, FAN
0002-414 FAN, 33CFM, MUFFIN
0062-052
ASSY, CABLE, DCB INTERCONNECT
0068-321
ASSY, CABLE, LSDT V/F TRANSITION
0068-393
ASSY, CABLE, GALVO CONTROL
0068-499
ASSY, CABLE, LSDT DC POWER DIST
0068-873
ASSY, CABLE, I-LOCK/I-LOCK SW
0069-977
ASSY,CABLE,PMT HV ADJ/PWR
0070-124
ASSY, CABLE, PWR DIST, D-DISC
0070-128 ASSY, WIRE, FUSE HLDR, ODISC
0070-384
ASSY, CABLE, REF LED/SCREEN PRESENT
0070-385
ASSY, CABLE, LED INDICATOR
0070-634
ASSY, CABLE, LASER DIODE DRIVER, LS135
0071-016
ASSY, CABLE, PMT/ LASER DIODE DETECT
0088-377 INSULATOR, GALVO-GALVO MOUNT
0088-777 GALVO, SCANNER
0002-319 P/S, LIN, +/-12V & +/-15V
0002-808 CLAMP, 1" FL CBL, ADH
0013-882 TERMINAL, RING, #8
0034-027 BEARING, BALL .250 BORE
0034-877 GUARD, FAN, 2.8 X 3.0, CHROME
0035-039-01 STDF, 6-32 X 3/8, M/F
0035-887 AY, CBL, PWR CORD, 10', HOSP GRADE
0037-291 WHEEL, IDLER
0048-048 SCREW, SHOULDER 1/4 X 5/16, 10-32
0048-109 RING, RET, .25 ID
0056-584 MOUNT, CABLE TIE
0080-042 PLATE, PMT TOWER
0081-789 ANCHOR, SPRING
0082-886 POWER SUPPLY, TRIPLE VOLT
0085-296 CONN, POWER ENTRY MODULE
0085-466 PANEL, MIRROR/LENS ACCESS
0085-482 PLATE, DACQ, CABLE D-SUB
0085-513 FUSE, 1.5A, SLO-BLO
0088-883 SCREW, HEX JACK
0088-802 GROMMET,3/16ID, 3/32 GRV
0088-810 GROMMET, RUB, 1/4ID, 3/32 GRV
0088-824 GROMMET, 1/2 DIA, 3/32 GRV
0088-363 CLAMP, CABLE, 2.00"
0088-400 BRACKET, GALVO DRIVER PCA
0088-407 FUSE, 1A, SLO-BLO
0088-588 TAPE, SCOTCH, F-9473PC
0088-736 INSULATOR, GALVO PCA
0088-136 INSUL, SCR, 6X3/16LG, NYL
0088-278 SPRING, EXT, .240 OD, 1" LONG
0088-361 SHIELD, DACQ
0088-416-01 FUSE, 250V, 315mA
0088-444 COVER, MAIN, LSCR
0088-812 FUSEHOLDER
0088-782 STDF, HEX, F, 6-32, .38L
0088-788 FOOT, RUBBER, 3/4 X 1/4
0088-815 SW, INTERLOCK, DPST, LOW CURR
0088-834 COVER, DUST, MIR, GALVO ROOF
0088-880 MIRROR, SWM GALVO ROOF
0088-875 CHEAT, INTERLOCK SWITCH
0088-811 PULLEY, GRTHD, #1.017, LSDT
0070-088 BELT, FLAT .30 X 30.15 LG
0070-067 SHIELD, POWER SUPPLIES
0070-124 ASSY, CABLE, AC PWR, ODISC
0070-338 COVER, PMT PCA
0070-339 GUIDE, FRONT, SCREEN EXIT
0070-340 GUIDE, REAR, SCREEN EXIT
0070-483 ADAPTER, SINGLE OPTICS
0070-490 MOUNT, DC MTR/GEARHD, LS114
0070-588 MOUNT, GALVO, LS135
0088-585 MOUNT, GALVO, SAND CAST
0070-613 ARM, BELT TENSION, LS135
0070-778 BRKT, REAR, INTLK SW, LS135
0070-781 BRKT, FRONT, INTLK SW, LS135
0070-783 RETAINER, RING, SLOTTED
0070-877 MIRROR, GALVO, AC, REPLICATED
0070-911 HANGER, X-IT TRAY, RH, LS135
0070-910 HANGER, X-IT TRAY, LH, LS135
0070-924 GASKET, EMI SHLD
0071-288 PWR SPLY, PMT, 1000V, W/SHLD
0068-215
KIT, SHIPPING LSCR
0088-705 BAG, ANTI-STATIC, PNC, PINK
0067-507 WRENCH, COMBINATION, 7/16
0071-343 S/W, SYS, KIT, V1.30, LSDT
0085-521 SHIPPING CRATE, LSDT
0088-883 SCREW, 1/4-20 X 1.25 LG, HEX HEAD
0071-312
DOCUMENTATION, SYSTEM LS135
0071-317 DWG, AC/DC WIRING, LS135
0071-318 DWG, SYSTEM INTCON, LS135
0071-711 LUMISCAN 135, OPERATOR'S REFERENCE GUIDE
0070-719 PROC, FNL SYS ALIGN & TEST, LS135
0070-713 FORM SYS ALIGN CHK LIST, LS135
0071-079 PROC, SYSTEM ASSY, LS135
0071-313
ASSY, LABEL, LOCATIONS, LS135
0008-802 LABEL, LASER DANGER
0033-217 LABEL, I.D., P/N, S/N, MFG DA
0058-053 LABEL, PROTECTIVE GROUND
0065-733 LABEL, HI-POT TEST COMPLETE
0088-530 LABEL, INPUT VOLTAGE
0068-540 LABEL, LASER, TUV
0088-230 LABEL, UL, CSA, TUV + CE
0088-944 LABEL, DANGER, CLASS IIIB
0088-967 LABEL, LASER INTLK DEFEAT
0070-382 LABEL, CAUTION, HEAVY
0070-931 LABEL, NAMEPLATE, LS135
0071-230 LABEL, 230 VOLTS, .5 X 2.2
0071-231 LABEL, 240 VOLTS, .5 X 2.2

REVISION HISTORY

EC	REV	DESCRIPTION	DATE	CHG BY	APPROVED
	A	PROTOTYPE	12/04/97	J. HUNT	
	B	DELETED UNUSED PARTS, ADDED NEW PARTS	12/10/97	J. HUNT	
	C	ADDED P/N 0070-611 TO 0070-574 ASSY, P/N 0070-613 TO 0070-573 ASSY, 0070-636 TO 0070-576 ASSY, 0070-633 AND 0070-635 TO 0070-636 PCA, 0070-549 TO 0070-451 PCA, 0070-637, 0070-650 AND 0070-651 TO 0070-574 ASSY. ADDED 0070-640 DACQ5135 PCA. CHG 0068-652 TO 0070-634 CABLE ASSY. DELETED CABLE ASSY 0064-363	12/18/97	J. HUNT	
2174	D	ADDED P/N 0019-145 TO ASSY 0070-598 ADDED P/N 0070-568 TO 0070-576 DELETED ASSY 0070-568 DELETED 0070-802 FROM 0070-574, ADDED 0070-604. DELETED 0070-581 FROM 0070-579, ADDED 0070-582. CHG 0068-774 TO 0070-234 & DEL 0068-622, 0068-623, ADDED 0070-236, 0070-235. CHG 0068-767 TO 0070-232 & DEL 0068-622, 0068-623, ADDED 0070-236, 0070-235. CHG 0070-640 TO 0070-438 & DEL 0070-642 ADDED 0070-705. MOVED 0070-549 FROM ASSY 0070-451 TO ASSY 0070-491. ASSY 0070-573, DEL 0068-416-02, 0070-571, 0070-587, ADDED 0019-608, 0070-587, 0070-893. CHG 0068-283 TO 0068-215, 0068-675 TO 0070-667 & 0068-682 TO 0065-521. DEL 0070-587 FROM ASSY 0070-573.	01/26/98	SEC	
	E	ON ASSY 0070-577, DELETE 0064-402, ADD 0070-783. ON ASSY 0070-576, ADD 0068-783, 0070-710, 0070-718 AND 0070-701. ON ASSY 0070-574, ADD 0070-762. ON ASSY 0070-598 ADD 0070-908, 0070-909. ON ASSY 0070-573 ADD 0070-781, 0070-778, 0070-911, 0070-910 AND ASSY 0070-124, DELETE 0070-433, 0070-477 AND 0070-681.	04/23/98	SEC	
	F	ZONE D/8 ADD 0071-141, 0070-605, 0070-893, 0070-783. ZONE B/8 CHG 0070-566 TO 0070-840, 0070-636 TO 70-092. ZONE A/7 ADD 0070-937, 0070-945 TO 0070-574. ZONE C/8 CHG 0068-681 TO 0070-853, 0068-197 TO 0070-254 AND 0068-196 TO 0070-253. ZONE D/4 ADD 0070-951 TO 0070-598.	07/20/98	SEC	
	G	ZONE B,C/4 DELETE 0064-583, 0064-822, 0065-717, 0065-725, 0065-741, 0068-793, 0068-858, 0068-858, 0068-860. ADD 0070-124, 0070-128. CHG REV.	07/24/98	SEC	
	H	ZONE B/5 DELETE 0068-985, 0068-785, 0068-835. ZONE B/5 ADD 0071-288, 0070-931. ZONE D/4 ADD 0070-950.	08/02/98	SEC	
	I	ZONE D/8, MOVE 0071-141 TO ZONE D/4. ZONE B/8 ADD 0070-633, CHG 0070-092 TO 0071-092. ZONE C/7 CHG 0068-928 TO 0071-325. ZONE B/7 ADD 0070-688. ZONE C/8, ADD 0071-141. ZONE B/6 CHG 0070-438 TO 0070-735. ZONE B/5 CHG 0068-866 TO 0071-016, DELETE 0068-930. ZONE A/5 DELETE 0070-438, ADD 0070-128, CORRECT SPELLING. ZONE A,B/5 ADD 0068-512, 0068-361, 0048-109, 0081-788, 0070-783, 0070-483, 0068-834, 0070-924. ZONE B/4 ADD 0071-312 AND 0071-313.	08/24/98	SEC	
	J	ZONE B/8 ADD 0071-371. ZONE C/4 ADD 0071-343. ZONE B/4 ADD 0008-802, 0033-217, 0035-665, 0044-747, 0058-053, 0068-540, 0068-230, 0068-944, 0068-967, 0070-382, 0070-931.	10/13/98	SEC	
	K	ZONE B/3,4 ADD 0070-719, 0070-713, 0071-079.	10/16/98	SEC	
	L	ZONE B/,4 CHG 0044-747 TO 0068-530 AND 0035-665 TO 0071-230.	10/22/98	SEC	
2357	M	REV CHANGES "E" THRU "M" INCLUDED IN EC 2357. ZONE B,C/4 DEL 0019-609. ADD 0070-877. ZONE A,B/6,7 MOVE 0071-222. ZONE B/4 ADD 0071-231.	11/08/98	SEC	

NOTES:

1. THIS DRAWING IS FOR REFERENCE ONLY AND SHALL NOT BE USED TO MANUFACTURE UNITS.

DESIGNED J. HUNT	DATE 12/04/97	LUMISYS INC. Sunnyvale, CA	
CHECKED	DATE		
DRAWN J. HUNT	DATE 12/04/97	TITLE TREE, PRODUCT, LS135	
APPROVED	DATE		
INITIAL APPLICATION LS135		SIZE D	DWG. NO. 0070-578 REV M
SCALE: N/A			FILENAME: 70-5781M.DWG SHEET 1 OF 1

KODAK General Radiography Software

Administrator Reference Guide

Health Imaging

Image Processing Presets

You can configure an image process to Save As an option for display in the ***Image Display*** window's toolbar Process drop-down list.

1. Click ***Set Image Processing*** from the ***Image Display*** window toolbar.
2. Select a *Body Part* from the drop-down list.
3. Select a *Position* option that corresponds to the patient position on the active image.
   - A/P — Anterior/Posterior
   - P/A — Posterior/Anterior
   - LAT — Lateral
   - OBL — Oblique
   - DEC — Decubitus
4. Select a *Grid Removal* option of *None, Horizontal or Vertical*.
5. Click ***Save As***. The Save As Preset dialog box is displayed. There are nine spaces in which a preset value can be saved.
6. Select one of the spaces in which to save the current settings. You can overwrite a preset by selecting it. (Regardless of the space-number selected, when a preset is displayed in the Process drop-down list, it is displayed in the order in which it was originally saved.)
7. Click **OK**.

Note: After nine preset values have been saved, you will have to overwrite one of the presets if you wish to add new processing to the Process list.

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Electronic Radiology Laboratory
Mallinckrodt Institute of Radiology
Washington University School of Medicine
510 S. Kingshighway Blvd.
St. Louis, MO 63110

as part of the 1993–1995 DICOM Central Test Node project for, and under contract with, the Radiological Society of North America.

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Section 1

Requirements, Networking, and Installing/Uninstalling

Introduction

About KODAK General Radiography Software

KODAK General Radiography Software, running on Microsoft Windows 2000 operating system, digitizes computed radiography (CR) plates—using only the ACR-2000 desktop scanner—or radiology films using one of the LS series of desktop scanners. The scanned image files are DICOM 3.0-compliant. You can set up the software to perform DICOM operations of sending, querying, retrieving, printing, and archiving image files over a local area network (LAN) or wide area network (WAN) to other DICOM nodes.

Use KODAK General Radiography Software to:

- Scan CR plates or radiology films and produce digitized images for use with a primary diagnostic viewing station
- View and manipulate images in thumbnail and full-sizes
- Annotate images
- Create Patient and Study information assigned to images
- Apply image processing and window/level capabilities to images
- Send images to other DICOM nodes in compressed or uncompressed formats
- Print images to a Windows printer or a DICOM printer
- Perform quality assurance self-test functions
- Use the drag-and-drop feature to move images in the Patient list
- Query a modality worklist broker to download worklist information about scheduled procedures and related patient demographic data.

- Query and Retrieve to and from other DICOM nodes
- Archive and Retrieve patient records to and from a local or DICOM archive
- Restore unarchived CR images, as well as permanently delete unarchived CR images, from the Recycle Bin
- Perform administration functions, including communication, scanner, window level, image processing, application settings, and modality settings, as well as view KODAK General Radiography Software activity from log files.

Variations in Program Performance

KODAK General Radiography Software is optimized to run on the hardware and software described in *System Requirements* on page 5. Program performance varies depending on your hardware configuration. The program performs faster when no DICOM communications are running in the background. Small image files display more quickly than large image files.

What is DICOM 3.0?

KODAK General Radiography Software creates Digital Imaging and Communications in Medicine (DICOM) 3.0-compliant images. The DICOM standard defines formatting, storage, and transmission protocols for digital images. These protocols allow medical images and the clinical information associated with those images to be captured, transferred, viewed, and manipulated with DICOM-compatible hardware and software. The DICOM standard defines a storage hierarchy of Patient, Study, Series, and Image.

Who is This Guide For?

This guide is written for System Administrators who are responsible for setting up and administering KODAK General Radiography Software.

KODAK General Radiography Software uses common Windows commands. You will need familiarity with using the mouse; opening, closing, maximizing, and minimizing windows; using scroll bars; selecting commands from a menu; and selecting options from a dialog box. Refer to your *Microsoft Windows User Guide* for more information.

What is in This Guide?

This guide is divided into three sections:

- ***Section 1: Requirements, Networking, Installing and Uninstalling,*** includes system requirements, networking, hardware installation, program installation, and uninstallation.
- ***Section 2: Setting Up KODAK General Radiography Software***, includes information on the Self-Test, User Rights, making system-level changes to KODAK General Radiography Software, including changing ACR-2000 scanner self-test attributes, creating window/level values, editing scanner type and resolution settings, selecting modalities for radiology film digitizers, changing image processing attributes, customizing DICOM communications, application settings, setting-up nodes, and Processing Presets.
- ***Section 3: Maintaining KODAK General Radiography Software,*** includes information about modifying node addresses, the database utility, deleting images, common log messages, and troubleshooting information.

System Requirements

Minimum Hardware Requirements

KODAK General Radiography Software is optimized to run on the hardware and software listed on the Hardware Compatibility List included with this software. Program performance varies depending on your hardware configuration. The program performs faster when there are no DICOM communications are running in the background. Small image files display more quickly than large image files.

Hardware	Requirements
PC Platform	Intel 400 MHz Pentium
Memory	384 MB RAM for scanners LS 75 and LS 85. All other scanners require 256 MB RAM.
Monitor	17-inch color **WARNING: Configure the monitor for square pixels; otherwise, the image aspect ratio could be incorrect.**
Video Board	8 MB video display board capable of 1024K x 768K screen resolution at 16M colors
High Resolution Board	8 MB video display board capable of 1280 x 1600 with 256 colors
Local Hard Drive	6 GB

Hardware	Requirements
Scanner	Lumiscan scanner with a SCSI or Data Control Board (DCB) interface
Mouse	2-button mouse
CD-ROM Drive	Standard
Ethernet Card	NDIS-compatible version 3.1
Network Connection	10/100 Base-T Ethernet

Software Requirements

Software	Requirements
Operating System	Microsoft Windows 2000 Professional operating system with Service Pack 1.
Drivers	Lumiscan LSDT version 2.5x for Windows NT 4.0

System Setup

WARNING: To optimize system performance, ensure you do the following:

- Use only approved hardware specified in the Hardware Compatibility List found in the KODAK General Radiography Software installation package.
- Follow the hardware manufacturers' configuration and set-up instructions.
- Follow the hardware manufacturers' guidelines for periodic

system maintenance.

Managing Disk Space

At program startup and at the beginning of each scan operation, the application reads the available space on the drive where the directory for images is located, then permits users to scan CR plates or radiology film if there is enough space. If there is not enough space, a message advises the user to free up disk space. Disk space can be made available by deleting patient records.

If users are scanning CR plates, they can permanently delete a Patient or a Study from the local database as long as there are no images or only archived images assigned to that Patient or Study. Before permanently deleting patient records, users or administrators should first archive the records to a local or DICOM archive. See *Creating a Local Archive* on page 53 or *Creating a DICOM Archive* on page 53. When scanning radiology films, users can permanently delete Patients or Studies from the local database to free up disk space at any time.

Networking

KODAK General Radiography Software exchanges DICOM 3.0 compatible images through the Microsoft communications setup using a Local Area Network (LAN). To use a LAN (typically within an institution), you connect through an Ethernet card that is installed in your computer. If you are setting KODAK General Radiography Software to communicate through a Wide Area Network (WAN), you need to provide the necessary LAN-WAN dial-on-demand routers and configure them in conformance with their manufacturer's specifications. Refer to the WAN hardware reference guide.

The instructions in this chapter represent one path to installing Microsoft communications on a basic LAN system. This section does not cover information on configurations that are specific to an individual computer, such as network set-up options or security setups. For more information, refer to your Windows 2000 Professional documentation.

After the communications are set up, individual address entries can be set up within KODAK General Radiography Software. (For instructions on setting up nodes and addresses, see *Setting Up Nodes* on page 45).

Setting Up LAN

TCP/IP Addresses

To connect to a LAN through an Ethernet connection, you must install the TCP/IP protocol. To configure or ensure TCP/IP protocol is installed on your computer, follow these instructions:

Note: *To install the TCP/IP protocol, you must have an IP address, subnet mask, and default gateway (if required).*

1. On the desktop, click Start, scroll to **Settings**, then click

Control Panel.

2. In the ***Control Panel*** window, double-click the ***Network and Dial-up Connections*** icon.
3. Double-click *Local Area Connection* then click **Properties**.
4. Select Internet Protocol (TCP/IP) and click **Properties**.
5. If an IP address and a subnet mask are not entered, enter the IP address, subnet mask, and default gateway (if required).
6. Click **OK** to return to ***Local Area Connection Properties*** dialog box.
7. Click **OK** on the ***Local Area Connection Properties*** *dialog box*.
8. Click **Close** from the ***Local Area Connection Status*** dialog box.

Installing/Uninstalling

KODAK General Radiography Software installation includes hardware and software installation. The hardware installation consists of connecting a 50-pin cable or a SCSI cable from the back of the scanner to the data control board in your computer. The software installation consists of installing the KODAK General Radiography Software.

Hardware Installation

The data control board (DCB) or SCSI interface must be installed by a certified technician. The LSDT driver must be installed and calibrated by a certified service provider.

Note: *If you change scanner models on a workstation after KODAK General Radiography Software is installed, you must use the Setup feature of the application to select the appropriate scanner model and restart the program. For more information, see Scanner Settings* on page 29. *You will also need to review Look Up Table (LUT) configuration in the manual for the scanner model attached to your workstation.*

Software Installation

Note: *You* **must** *have Microsoft Windows 2000 with Service Pack 1 installed on the workstation platform before installing KODAK General Radiography Software.*

Display Properties —1K (High-Resolution Grayscale Portrait Monitor)

KODAK General Radiography Software is optimized for use on a high-resolution grayscale portrait 1K-monitor system at a screen resolution of 1200 by 1600 pixels with 256 (8-bit) colors and the display of small fonts from the operating system.

To set screen resolution, display colors, and enable small fonts:

1. On the desktop, click Start, select **Settings,** then **Control Panel.**
2. On the ***Control Panel*** window, double-click **Display.**
3. On the ***Display Properties*** dialog box, select the **Settings** tab.
4. From the ***Screen Area*** slider bar:
   - Verify that the desktop area (screen resolution) is set to **1200 by 1600 pixels**.

     – or –
   - Move the slider bar **Less** or **More** until **1200 by 1600 pixels** is displayed, then click **Apply.**
5. From the ***Colors*** drop-down list:
   - Verify that colors are set to **256 (8 bit)**.

     – or –
   - Select **256 (8 bit) Colors**, then click **Apply.**
6. Click Advanced... and from the ***Font Size*** drop-down list:
   - Verify **Small Fonts** is active. Click **OK.**

     – or –
   - Select **Small Fonts,** then click **OK.**

     In the ***Change System Font*** dialog box, select **OK.**
7. Restart your computer if you have changed system settings.

Display Properties —SVGA (non-diagnostic viewing)

Note: *Ensure that the video card installed on your platform supports a screen resolution of 1024 x 768 with 16M colors.*

KODAK General Radiography Software can be used on a non-diagnostic SVGA system at a screen resolution of 1024 by 768 pixels with 16,777,216 (24 bit) colors and the display of small fonts from the operating system.

To set screen resolution, display colors, and enable small fonts:

1. On the desktop, click Start, select **Settings,** then **Control Panel.**

2. On the ***Control Panel***, double-click **Display.**
3. On the ***Display Properties*** dialog box, select the **Settings** tab.
4. From the ***Screen Area*** slider bar:
   - Verify that the desktop area (screen resolution) is set to **1024 by 768 pixels**.

     – or –
   - Move the slider bar **Less** or **More** until **1024 by 768 pixels** is displayed, then click **Apply.**
5. From the ***Colors*** drop-down list:
   - Verify that colors are set to **16777216 (24 bit)** or **True Color**.

     – or –
   - Select **16777216 (24 bit) Colors** or **True Color**, then click **Apply.**
6. From the Settings tab, select **Advanced**...
7. From the ***Font Size*** drop-down list:
   - Verify **Small Fonts** is active. Click **OK.**

     – or –
   - Select **Small Fonts,** then click **OK.**

     In the ***Systems Setting Change*** dialog box, select **Yes** to restart your computer. Click **OK.**
8. Click **OK** in the dialog boxes that display, informing you that font changes will apply when Windows restarts.
9. From the ***Display Properties*** dialog box, click **Close.**

   Windows restarts.

Software Upgrades

If you are upgrading KODAK General Radiography Software from a previous version, follow the steps below, install the software, then Run DB_Convert.exe to re-import all images as non-archived images.

Note: *To install KODAK General Radiography Software on your Windows 2000 Professional operating system, you must have Windows 2000 System Administrator privileges.*

Upgrade Steps

To upgrade KODAK General Radiography Software:

1. Open the ***Setup*** window and record your settings for each tab. You will need to restore these settings after you upgrade your program.
2. Copy your current address book to a floppy disk. (Your address book will be retained during the new installation, but print it as a precaution.)
3. Delete archived patients; otherwise, when you run DB_Convert.exe, archived images will be reimported as well as unarchived images.
4. Uninstall the previous version and reboot the system.
5. Install and reboot KODAK General Radiography Software.
6. Open the ***Setup*** window and restore the settings on each tab that you recorded in step 1.
7. Run DB_Convert.exe which will re-import all images as non-archived images.

   Note: *KODAK General Radiography Software must be closed to run DB_Convert.exe.*

Installing the Software

Use the InstallShield Wizard to install the KODAK General Radiography Software by doing the following:

1. Insert the KODAK General Radiography Software installation CD into your CD-ROM drive.
2. On the desktop, start the Setup program by doing one of the following:

- Click **Start** and scroll to ***Run....*** In the ***Run*** dialog box, type *x:\setup.exe* (where *x* is the label of the CD-ROM drive), then click **OK.** You can also use **Browse** to locate the KODAK General Radiography Software file *Setup.exe*. Double-click *Setup.exe*, then click **OK.**

  – or –

- Use Windows 2000 Explorer to locate the KODAK General Radiography Software *Setup.exe*, then double-click *Setup.exe*.

1. From the InstallShield Wizard window, click **Next**.
2. Type the *User Name* and *Organization* name, select the radio button labeled “Anyone who uses this computer (all users)” or “Only for me (User Name)”, then click **Next**. Choosing “Anyone...” will install shortcuts and registry entries for all users of the computer. Choosing “Only for me...” will install shortcuts and registry entries only for the current user.
3. Click **Next** to install the program files to the displayed folder, or click **Change** to select a different destination directory folder.

Note: Do not install the program in a directory with a blank (such as c:\Program Files\KODAK General Radiography Software).

4. Click **Install** when you’re ready to install the program, or click the **Back** button for your last chance to change installation settings. The installation status is displayed.
5. After the Installation Wizard installs the program, the Setup Applet allows you to configure the ***Setup*** window. For information on configuring the ***Setup*** Window, see *Setup Window* on page 25.

Note: *To ensure that there is enough disk space for program files and scanned images, locate the folder for the image database on the workstation drive that has the most available free space.*

6. Click **OK**. The Readme file is displayed.
7. Close Notepad.
8. Click **Finish**.
9. If the installation is successful, click **Yes** to reboot your system.

Uninstalling the Software

When you use the uninstall procedure to remove the program from your computer, you uninstall all program files and the start-up menu shortcuts for the program. However, you must manually delete the address entry database, patient database, and image files.

To uninstall the KODAK General Radiography Software:

1. Exit all Windows programs.
2. On the desktop, click **Start,** scroll to **Settings,** then click **Control Panel.** The ***Control Panel*** window opens.
3. Double-click **Add/Remove Programs.** The ***Add/Remove Programs*** dialog box opens.
4. Select ***KODAK General Radiography Software*** and click ***Remove***.
5. On the ***Add/Remove Programs*** dialog box, click **Yes**. The uninstall procedure removes the program from your computer.
6. On the ***Add/Remove Programs*** window, click **Close**.

Section 2

Setting Up the KODAK General Radiography Software

Scanner Self-Test

WARNING: Run the Self-Test regularly to ensure acceptable ACR-2000 performance.

At program startup and at any time you click **Self-Test** (found on the Patients toolbar), the program performs a quality assurance self-test function—only on an attached ACR-2000 scanner—to verify the ACR-2000 meets acceptable performance standards. Be sure you perform the ACR-2000 self-test function at least once per day.

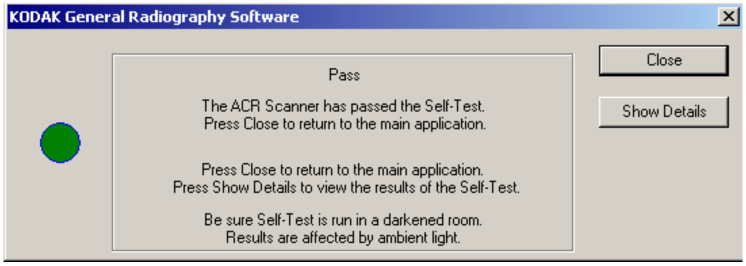
The self-test function creates output files that report the overall status of the ACR-2000 scanner on the basis of self-test results. You can view results of the self-test functions via:

- The ***Status*** window
- Printed test report
- History file

Note: Self-test results are affected by ambient light.

Status Window

From the Status window, you can view a status message, and you can expand the window to display the self-test results.



Pass

The ACR Scanner has passed the Self-Test.
Press Close to return to the main application.

Press Close to return to the main application.
Press Show Details to view the results of the Self-Test.

Be sure Self-Test is run in a darkened room.
Results are affected by ambient light.

Status Message

The status message reflects the overall condition of the scanner:

- **Pass —Indicates all self tests have met optimum performance standards.**
- **Caution —Indicates while no self tests have failed, one or more self tests have not met optimum performance standards. Could also indicate an untested condition exists. Call for service as soon as possible.**
- **Warning —Indicates one or more self tests have failed to meet performance standards or that an error condition exists. Cease ACR-2000 operations and call for service immediately.**

Status Functions

The status functions provide capability for viewing the Status window.

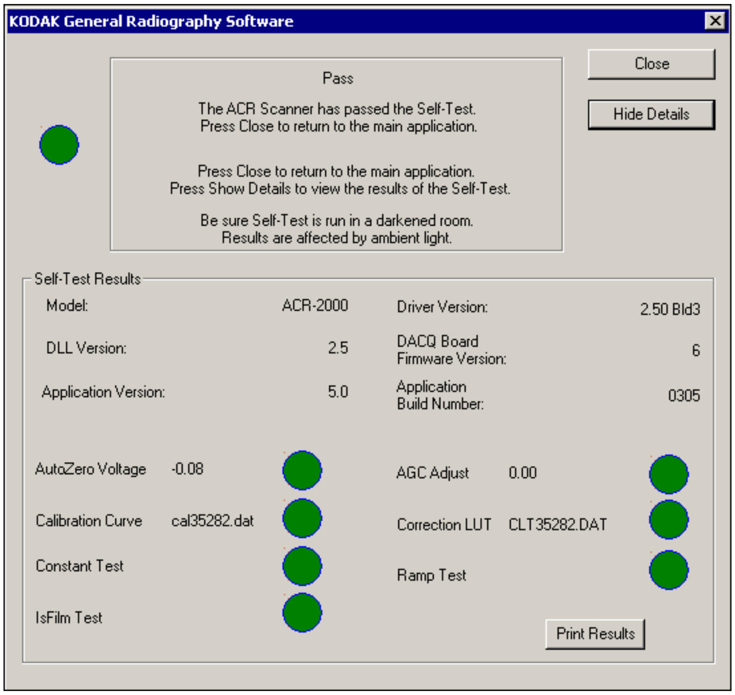
Close — Click **Close** to close the ***Status*** window.

Show Details — Click **Show Details** to expand the ***Status*** window to reveal detailed header information and test results containing pass, caution, or warning status.

Hide Details — Click **Hide Details** to collapse the *Status* window to show only the status message.

Self-Test Results

The self-test results section of the expanded ***Status*** window contains header information and results (pass, caution, warning) for each self-test function.



Pass

The ACR Scanner has passed the Self-Test.
Press Close to return to the main application.

Press Close to return to the main application.
Press Show Details to view the results of the Self-Test.

Be sure Self-Test is run in a darkened room.
Results are affected by ambient light.

Self-Test Results

Model:	ACR-2000	Driver Version:	2.50 Bld3
DLL Version:	2.5	DACQ Board Firmware Version:	6
Application Version:	5.0	Application Build Number:	0305

AutoZero Voltage	-0.08	●	AGC Adjust	0.00	●
Calibration Curve	cal35282.dat	●	Correction LUT	CLT35282.DAT	●
Constant Test		●	Ramp Test		●
IsFilm Test		●			

Header Information

The header information contains current hardware and software version information.

ACR-2000 Self-Test Functions

KODAK General Radiography Software returns results for each of the following ACR-2000 self-test functions. For support, contact your certified service provider.

- **AutoZero Voltage —** Verifies and reports the range of the self-adjustment voltage required to bring the input offset voltage in the logarithmic amplifier to the optimum level.
- **Automatic Gain Control (AGC) Adjust Voltage —** Verifies and reports the range of the self-adjustment voltage required to set the PMT (Photo-Multiplier Tube) high voltage to a value needed to achieve a desired overall sensitivity level.

- **Calibration Curve —** Verifies that the correct calibration curve data file exists. Also verifies that the file is correctly loaded in the system by reading the Cal Table contents from the ACR-2000 and comparing it with the file data.
- **Correction LUT —** Verifies that the Correction LUT (Look-Up Table) data file exists and is correct. Also verifies that the file is correctly loaded in the system by reading the CLUT contents from the scanner and comparing it with the file data.
- **Constant Test —** Generates a constant value and verifies it is written to image memory and read correctly.
- **Ramp Test —** Generates a wedge ramp and verifies it is written to image memory and read correctly.
- **IsFilm Test —** Verifies the scanner produces three peaks in the IsFilm signal during the edge finding process.

Error Condition

An error condition occurs when a test function is unable to return a test result; ERROR displays in the results column.

Untested Condition

An untested condition occurs when a test function was not performed; UNTESTED displays in the results column.

LSDT Error

An LSDT error occurs when communication with the scanner does not produce a test result; LSDT ERROR displays in the lower left corner.

Printed Test Report

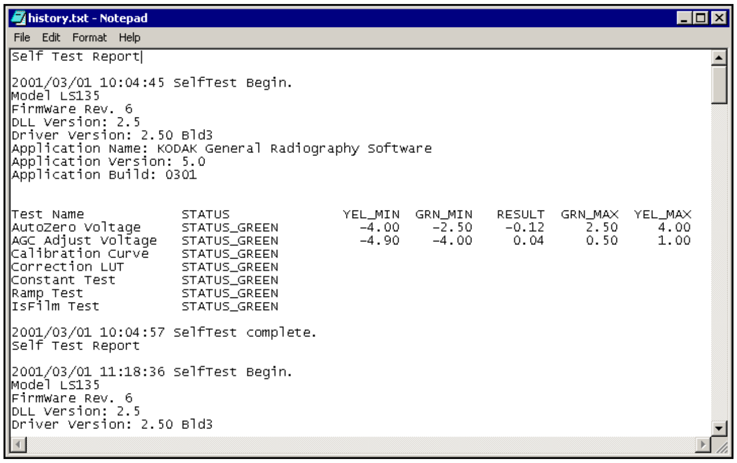
Print Results

Print Results

At the expanded ***Status*** window, click **Print Results** to print results of the last self-test performed. The Test Report prints to your default Windows printer. The report displays current version information and test results.

History File

Results of each ACR-2000 scanner self-test are recorded in the history file.



```
Self Test Report

2001/03/01 10:04:45 SelfTest Begin.
Model LS135
Firmware Rev. 6
DLL Version: 2.5
Driver Version: 2.50 Bld3
Application Name: KODAK General Radiography Software
Application Version: 5.0
Application Build: 0301


Test Name            STATUS              YEL_MIN  GRN_MIN   RESULT  GRN_MAX  YEL_MAX
AutoZero Voltage     STATUS_GREEN          -4.00    -2.50    -0.12     2.50     4.00
AGC Adjust Voltage   STATUS_GREEN          -4.90    -4.00     0.04     0.50     1.00
Calibration Curve    STATUS_GREEN
Correction LUT       STATUS_GREEN
Constant Test        STATUS_GREEN
Ramp Test            STATUS_GREEN
IsFilm Test          STATUS_GREEN

2001/03/01 10:04:57 SelfTest complete.
Self Test Report

2001/03/01 11:18:36 SelfTest Begin.
Model LS135
Firmware Rev. 6
DLL Version: 2.5
Driver Version: 2.50 Bld3
```

To open the history file:

1. On the desktop, click **Start,** select **Programs, Accessories,** then click **Notepad.**
2. Select **File** from the menu bar and scroll down to **Open...**
3. Open the contents of the DI-3000 folder.
4. Double click **history.txt.** The notepad displays all self-test activity.
5. To view the results of the latest self-test, scroll to the end of the history file.

User Rights

User rights are set-up in Windows 2000. The following table lists KODAK General Radiography Software rights for Administrators, Power Users, and (Standard) Users.

Note: Some of the windows for the functions listed below can be viewed by User’ s without Administrative rights, but the modifications to the windows cannot be saved.

☑ = Rights ☒ = No rights

Functions	Admin.	Power User	(Standard) User
Address Book (Edit/Delete)	☑	☒	☒
Recycle Bin (Delete)	☑	☒	☒
Application Setup	☑	☒	☒

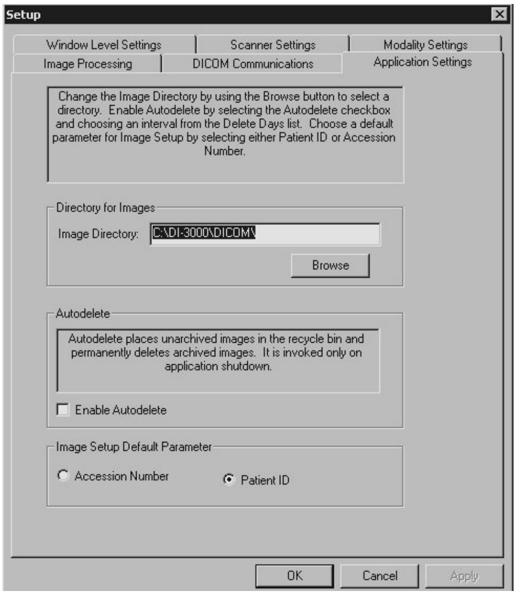
Functions	Admin.	Power User	(Standard) User
Save Scanning Settings for Image Setup	☑	☑	☒
Set Default in Broker Query	☑	☒	☒
Save Processing Presets	☑	☒ Can only use one time as needed, but not save	☒ Can only use one time as needed, but not save
Save last SpeedSend Destination	☑	☒	☒
Save Wizard Destination Settings	☑	☒	☒
Wizard (Setup Window)	☑	☑	☒

Setup Window

The **Setup window** allows you to configure and modify window/level, scanner, modality, image processing, DICOM communications and application settings in the KODAK General Radiography Software.

You can access the Setup window three ways:

- During installation, the window is automatically displayed at the end of the Installation Wizard.
- Click **Start**, scroll to ***Programs***, select Eastman Kodak Company, then select **Properties**.
- Click *Setup* on the *Patients toolbar*.


Setup
Window Level Settings
Scanner Settings
Modality Settings
Image Processing
DICOM Communications
Application Settings
Directory for Images
Browse
Autodelete
Image Setup Default Parameter
OK
Cancel
Apply

Change the Image Directory by using the Browse button to select a directory. Enable Autodelete by selecting the Autodelete checkbox and choosing an interval from the Delete Days list. Choose a default parameter for Image Setup by selecting either Patient ID or Accession Number.

Image Directory: C:\DI-3000\DICOM\

Autodelete places unarchived images in the recycle bin and permanently deletes archived images. It is invoked only on application shutdown.

☐ Enable Autodelete

○ Accession Number ● Patient ID

Settings Functions

- Click ***OK*** to save the current values entered on the tab and return to the program.
- Click *Cancel* to return to the program without saving changes.
- Click *Apply* to save the current values entered on the tab and stay in the *Setup* window.

For Setting-Up:

- Window/Level Settings, see *Window/Level Settings* on page 27.
- Scanner Settings, see *Scanner Settings* on page 29.
- Modality Settings, see *Modality Settings* on page 31.
- Image Processing Settings, see *Image Processing* on page 33.
- DICOM Communication Settings, see *DICOM Communications* on page 37.
- Application Settings, see *Application Settings* on page 39.

Window/Level Settings

You can create window/level settings, which users can apply, to manipulate images for display on a monitor. The purpose of window/ level settings is to enable users to:

- **Display images containing bit-depths greater than 8 bits**

  Most medical images have pixel values in the 10-bit to 12-bit range and most computer monitors have the capability to display 8-bit values. Window/leveling provides a way to reduce the number of pixel values in 12-bit images for display on 8-bit capable computer monitors.

- **Enhance images**

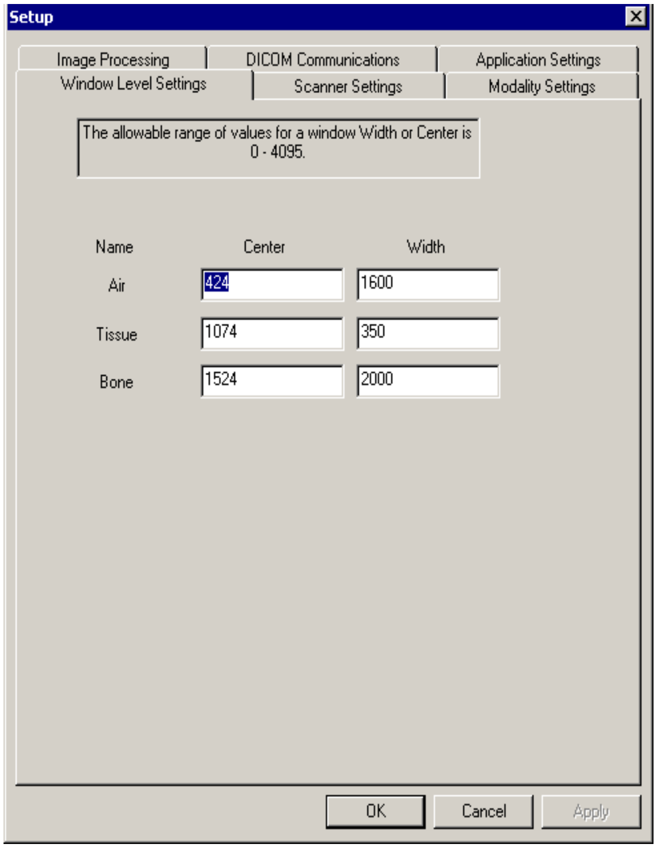
  When an image has low contrast, applying window/leveling provides a way to distribute the pixel values to increase the contrast over a larger range so that the resulting image appears more balanced.

Creating Window/Level Presets

You create custom window/level presets in KODAK General Radiography Software from the Window/Level Settings tab. The values you create for a selected window/level setting are then reflected in the **Window/Level Preset** toolbar buttons on the ***Image Display Window***.

The Window/Level settings are accessed from the ***Setup window***. To access the Setup window, see *Setup Window* on page 25.

- From the ***Setup*** window, click the Window/Level Settings tab.


Setup
Image Processing
DICOM Communications
Application Settings
Window Level Settings
Scanner Settings
Modality Settings
OK
Cancel
Apply

The allowable range of values for a window Width or Center is 0 - 4095.

Name	Center	Width
Air	424	1600
Tissue	1074	350
Bone	1524	2000

Window/Level Settings

- **Name**

  Displays the Window/Level Preset button names in the order they appear on the Image Display Toolbar. These names cannot be changed.

- **Center**

  Displays the current center value, which you can change, to increase or decrease brightness, for each Window/Level preset.

- **Width**

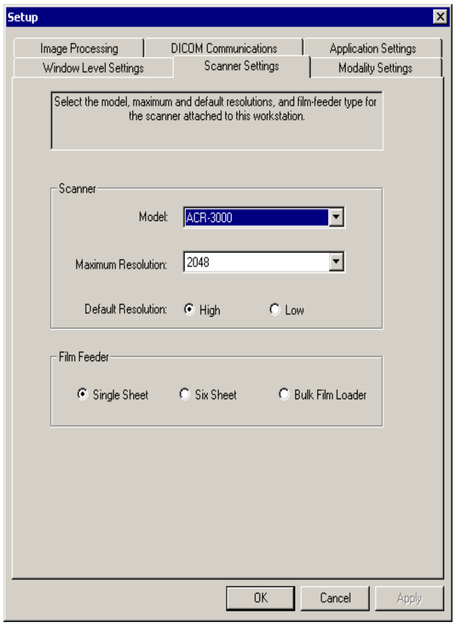
  Displays the current width value, which you can change, to increase or decrease contrast for each Window/Level preset.

Scanner Settings

You can change the Model, Maximum Resolution and Default Resolution values for the scanner attached to the application workstation.

The Scanner settings are accessed from the ***Setup window***. To access the Setup window, see *Setup Window* on page 25.

1. From the Setup window, click the *Scanner Settings* tab.


Setup
Image Processing
DICOM Communications
Application Settings
Window Level Settings
Scanner Settings
Modality Settings
OK
Cancel
Apply

Select the model, maximum and default resolutions, and film-feeder type for the scanner attached to this workstation.

Scanner

Model: ACR-3000

Maximum Resolution: 2048

Default Resolution: ● High ○ Low

Film Feeder

● Single Sheet ○ Six Sheet ○ Bulk Film Loader

- **Model**

  Select the scanner model attached to the application workstation.

Note: *If you select a scanner model that is not attached to the workstation, the application may not function.*

- **Maximum Resolution**

  Select the maximum resolution that you want for the attached scanner.

Note: *If you select a maximum resolution value not available for the scanner model that is attached to the workstation, the closest value available for that scanner will be implemented.*

- **Default Resolution**

  Select the default resolution (**High** or **Low**) for the attached scanner.

Film Feeder

Select the type of film feeder attached to your scanner.

- **Single Sheet**

  Permits the scanning of a single sheet of radiology film or CR plate.

Note: *This is the only functioning option available to users who have an ACR-2000 attached to the application workstation.*

- **Six-Sheet Feeder**

  Permits the scanning of radiology films from an attached six-sheet film feeder. Scanning continues until the film feeder is empty of film.

- **Bulk Film Loader**

  Permits the scanning of radiology films from an attached bulk film loader. Scanning continues until the bulk loader is empty of film.

Note: *The Six-Sheet Feeder and Bulk Film Loader options will only function if KODAK General Radiography Software is running on a workstation with an attached film digitizer and an optional film feeder.*

Note: You must restart KODAK General Radiography Software for Scanner changes to take affect.

Modality Settings

You create custom modality lists in KODAK General Radiography Software by selecting the desired modalities on the modality settings tab. The modalities you select are then available in the **Modality** list when you setup a patient on the ***Patient and Study Information Window*** and when you perform an ***AE*** *Query* and ***Worklist Query,*** in the ***Query*** dialog box**.**

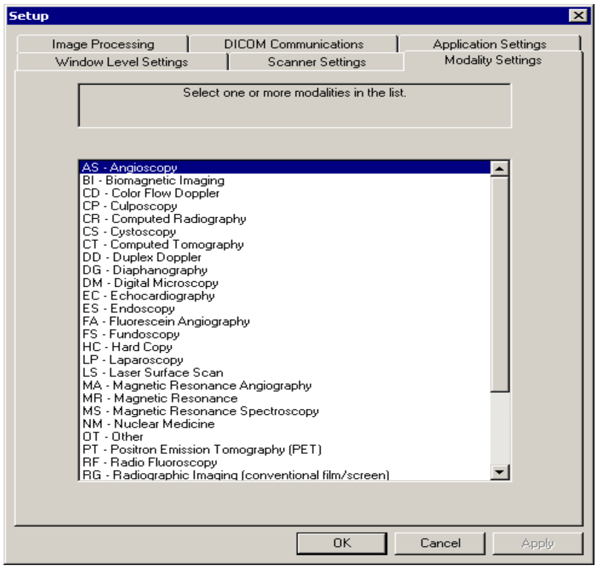
Note: Customized modality settings are applicable ***only*** for users of KODAK General Radiography Software for radiology film scanners. ***If a CR scanner is attached to the workstation, the only available modality value for scanning will be CR.***

A site may want to assign specific modalities to specific radiology film scanning stations or you may wish to query other sites on specific modalities. In this scenario, as a System Administrator, you can provide the requested modality values via ***Modality*** list on the ***AE Query*** and ***Worklist Query Dialog Box.***

Adding Modalities

The Modality settings are accessed from the ***Setup window***. To access the Setup window, see *Setup Window* on page 25.

1. From the Setup window, click the ***Modality Settings*** tab.


Setup
Image Processing
DICOM Communications
Application Settings
Window Level Settings
Scanner Settings
Modality Settings
OK
Cancel
Apply

Select one or more modalities in the list.

AS - Angioscopy
BI - Biomagnetic Imaging
CD - Color Flow Doppler
CP - Culposcopy
CR - Computed Radiography
CS - Cystoscopy
CT - Computed Tomography
DD - Duplex Doppler
DG - Diaphanography
DM - Digital Microscopy
EC - Echocardiography
ES - Endoscopy
FA - Fluorescein Angiography
FS - Fundoscopy
HC - Hard Copy
LP - Laparoscopy
LS - Laser Surface Scan
MA - Magnetic Resonance Angiography
MR - Magnetic Resonance
MS - Magnetic Resonance Spectroscopy
NM - Nuclear Medicine
OT - Other
PT - Positron Emission Tomography (PET)
RF - Radio Fluoroscopy
RG - Radiographic Imaging (conventional film/screen)

2. Select a modality or modalities. For multiple selections, CTRL-left click the selections or press SHIFT and PAGE DOWN to select a block.
3. Click **OK** or **Apply**.

Image Processing

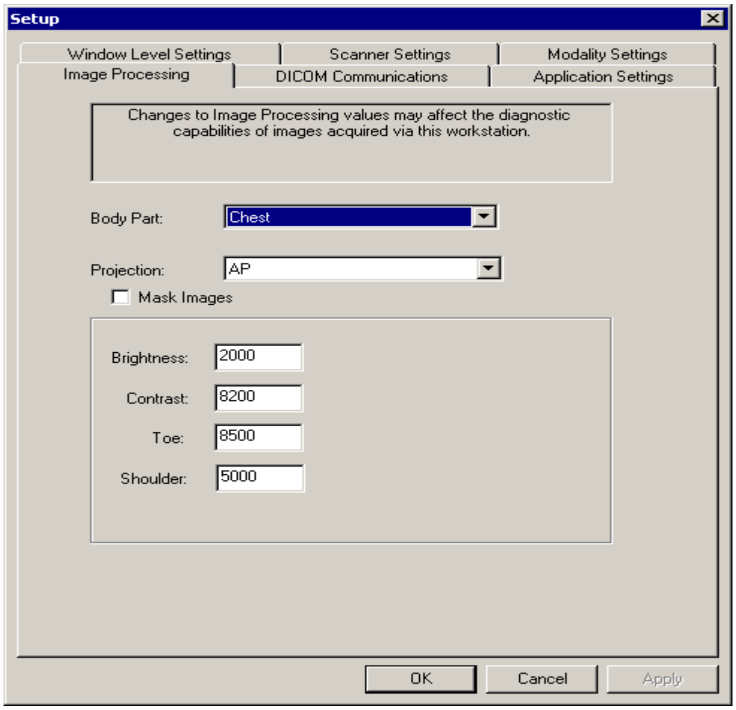
Note: Changes made to Image Processing values (Brightness, Contrast, Toe, and Shoulder) may affect the diagnostic capabilities of images acquired on your workstation. Changes to Image Processing values should ONLY be made at the direction of a certified service provider.

You can Edit the Brightness, Contrast, Toe, or Shoulder value for a selected Body Part and Position. These values are factory set and should not need to be changed. If they are changed, do so only at the direction of a certified service provider.

Changing an Image Processing Value

The Image Processing settings are accessed from the ***Setup window***. To access the Setup window, see *Setup Window* on page 25.

1. From the Setup window, click the Image Processing tab.


Setup
Window Level Settings
Scanner Settings
Modality Settings
Image Processing
DICOM Communications
Application Settings
OK
Cancel
Apply

Changes to Image Processing values may affect the diagnostic capabilities of images acquired via this workstation.

Body Part: Chest

Projection: AP

☐ Mask Images

Brightness: 2000

Contrast: 8200

Toe: 8500

Shoulder: 5000

You change image processing values from the Image Processing tab on the Setup window. N/A signifies that images will be processed with default values.

Image Processing

Body Part — Select the body part whose image processing values you want to change. If you are performing quality assurance testing with a test pattern, select Test Pattern.

Projection — Select the position of the body part whose image processing values you want to change.

Mask Images - Select if you want to black out all areas outside the image's region of interest, for a selected body part or projection.

Brightness — Enter a value, only at the direction of a certified service provider, between 0 and 10,000. A value entered outside this range will revert to the entry last saved.

Contrast — Enter a value, only at the direction of a certified service provider, between 0 and 10,000. A value entered outside this range will revert to the entry last saved.

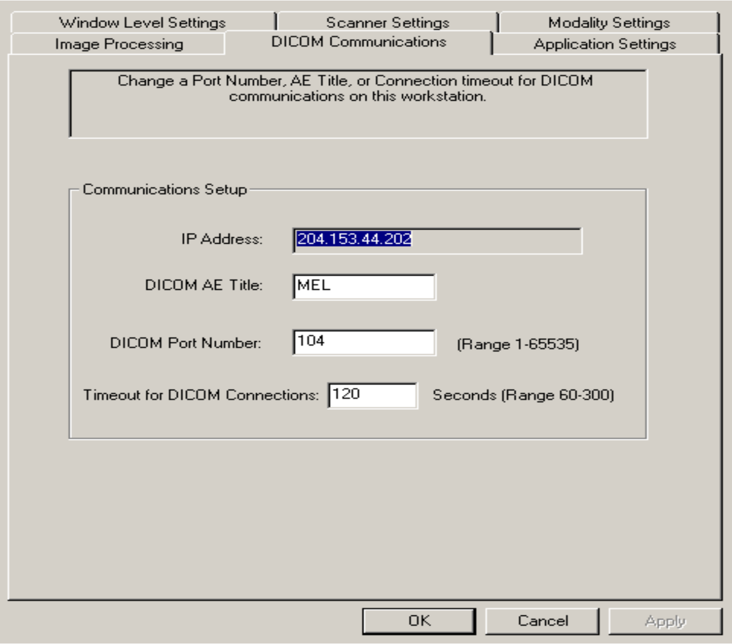
Toe — Enter a value, only at the direction of a certified service provider, between 0 and 10,000. A value entered outside this range will revert to the entry last saved.

Shoulder — Enter a value, only at the direction of a certified service provider, between 0 and 10,000. A value entered outside this range will revert to the entry last saved.

DICOM Communications

The DICOM Communications settings are accessed from the ***Setup window***. To access the Setup window, see *Setup Window* on page 25.

1. From the Setup window, click the ***DICOM Communications*** tab.



Window Level Settings
Scanner Settings
Modality Settings
Image Processing
DICOM Communications
Application Settings
OK
Cancel
Apply

Change a Port Number, AE Title, or Connection timeout for DICOM communications on this workstation.

Communications Setup

IP Address: 204.153.44.202

DICOM AE Title: MEL

DICOM Port Number: 104 (Range 1-65535)

Timeout for DICOM Connections: 120 Seconds (Range 60-300)

- **IP Address**

The workstation’ s Internet Protocol (IP) address is a read-only field retrieved from the operating system. This field displays the IP address set for your Ethernet card (LAN connection).

- **DICOM AE Title**

  The name of the application entity (AE) title assigned during application installation. You may change the AE Title by typing up to 16 alphanumeric characters.

- **DICOM Port Number**

  The port number assigned during application installation. You may change the Port Number by typing a numeric value between 1 and 65535.

- **Timeout for DICOM Connections**

  The time limit a DICOM connection waits in an inactive state before terminating the connection. The value set at application installation is 120 seconds. You may change the Timeout for DICOM connections by typing in a numeric value between 60 and 300 seconds.

Application Settings

You can modify the following application settings in the KODAK General Radiography Software:

- **Edit the Directory for Images directory path.**

  For network and desktop administration purposes, sometimes it is necessary to edit the directory path for acquired images created at application installation.

- **Setup and enable autodelete parameters.**

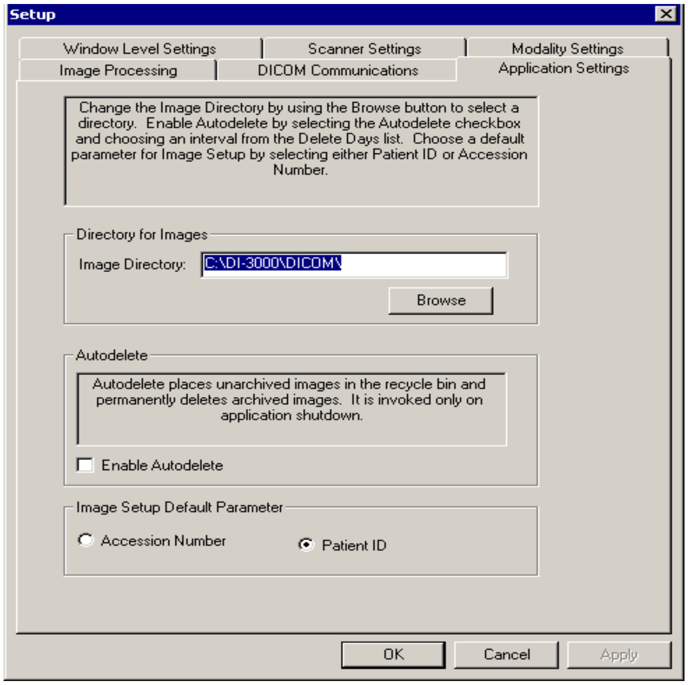
  The application settings tab permits you to enable and select a value for the number of days you want to keep archived images on a workstation.

- **Set the default cursor position on the Image Setup window.**

  Permits you to select a default cursor position on the Image Setup window for users. This option only applies to users of the ACR-2000 scanner.

The Application Settings are accessed from the ***Setup window***. To access the Setup window, see *Setup Window* on page 25.

- From the ***Setup*** window, click the ***Application Settings*** tab.


Setup
Window Level Settings
Scanner Settings
Modality Settings
Image Processing
DICOM Communications
Application Settings
Browse
OK
Cancel
Apply

Change the Image Directory by using the Browse button to select a directory. Enable Autodelete by selecting the Autodelete checkbox and choosing an interval from the Delete Days list. Choose a default parameter for Image Setup by selecting either Patient ID or Accession Number.

Directory for Images

Image Directory: C:\DI-3000\DICOM\

Autodelete

Autodelete places unarchived images in the recycle bin and permanently deletes archived images. It is invoked only on application shutdown.

☐ Enable Autodelete

Image Setup Default Parameter

○ Accession Number ● Patient ID

Directory For Images

- **Image Directory**

  The current directory path for the acquired images directory is displayed here. You can edit the path by clicking ***Browse...*** and selecting another directory.

Note: *It is highly recommended that your* ***Image Directory*** *be located on your local hard drive. If you choose to place your* ***Image Directory*** *on a network drive, you will not be able to access the directory in the event of a network failure.*

Autodelete

- **Enable Autodelete**

  Check this box if you want to enable the application’ s autodelete capabilities.

- **Delete Days**

  The application calculates age from an image’ s acquisition date. Select a value for the number of days that you want to keep images on the workstation. Archived images that fall outside this value will be permanently deleted on application shutdown. Unarchived images that fall outside this value will be placed in the Recycle Bin on application shutdown.

Image Setup Default Parameter

Select either the ***Accession Number*** or ***Patient ID*** option to set the default cursor position on the *Image Setup window*. This option only applies to users of the ACR-2000 scanner.

Compressed Images

You can send images to other DICOM nodes in compressed or uncompressed formats. Compressed files take less time to transmit, but lossy compressed files result in data loss and lower image quality. If an addressee is configured to receive lossy compression, a yellow triangle appears next to the nickname in the Nodes column on the Communications window.

Lossless/Lossy Compression

Image file compression may be lossless or lossy.

Lossless Compression — Compresses the image file and retains all the information in the data. Lossless compression allows the file to be completely recovered with decompression.

Lossy Compression — Reduces the amount of information in the data.

WARNING: Lossy compressed images may not be of diagnostic quality.

JPEG

KODAK General Radiography Software supports Standard JPEG and Enhanced JPEG compression.

Standard JPEG — Compresses the image as a unit. The available Standard JPEG compression ratios are:

Lossy ~ 5-10:1 Standard JPEG

Lossy ~ 10-20:1 Standard JPEG

Lossy ~ 15-30:1 Standard JPEG

Enhanced JPEG

Enhanced JPEG can ONLY be sent to Eastman Kodak Company viewing stations from KODAK General Radiography Software. Sending a Enhanced JPEG to a non-Eastman KODAK Company station may result in a non-displayable image.

The available Enhanced JPEG ratios are:

Lossy ~ 20-40:1 Enhanced JPEG

Lossy ~ 30-60:1 Enhanced JPEG

Lossy ~ 50-100:1 Enhanced JPEG

Lossy ~ 60-120:1 Enhanced JPEG

Note: All compression ratios listed are approximate. The actual compression yield depends on the image being compressed.

Setting Up Nodes

Setting Up DICOM Send and Receive Operations

KODAK General Radiography Software performs best when run across a local area network (LAN) using an Ethernet connection for DICOM operations. You can set up Address Entries to allow KODAK General Radiography Software to:

- Perform DICOM Send operations to individual and group sites.
- Perform and Accept DICOM Query operations to and from remote DICOM sites.
- Perform and Allow DICOM Retrieve operations to and from remote DICOM sites.
- Send images to a DICOM Printer.
- Store and retrieve images from a DICOM Archive.
- Query and retrieve patient demographic information from a Worklist Broker.

You can set up KODAK General Radiography Software to send and receive files to and from other DICOM nodes. When you send files, the status bar at the bottom of the screen displays the sending status. Also, you can create groups to display on the node list consisting of different node addresses.

Before sending images, make sure the target computer's Address, AE Title and Port Number are correctly set up. To set up addresses, see *Setting Up DICOM Node Addresses* on page 46. Your computer's Address, AE Title and Port Number may need to be in the target computer's Address Book.

Note: The program sends only the processed version of the image. If the user at the destination requires the unprocessed version, you must select the image, select Unprocessed from the Process drop-down list, save the image, and then send the unprocessed version.

Accepting DICOM Query Operations

You can set up the application to accept patient-level queries from other DICOM nodes. When your local database is queried, the workstation sends a list of patients that match the query criteria.

To set up KODAK General Radiography Software to accept query operations, make sure the target computer's Address has the corresponding Query AE Title and Port Number entered. Your computer's Address, AE Title and Port Number must be in the target computer's Address Book.

Busy Location

When a location is busy, the program completes the operation if the location becomes available before the program times out. For more information on timeout for DICOM connections, see *DICOM Communications* on page 37.

Closing the Program During DICOM Operations

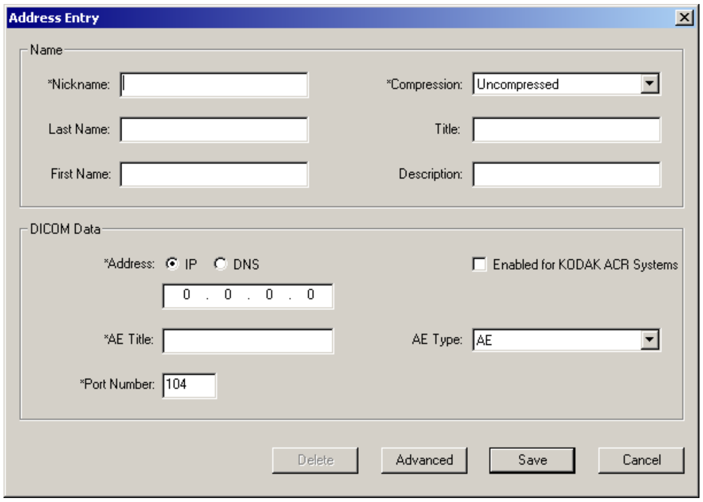
While DICOM operations are in progress, you cannot close the program. If you attempt to close the application while a DICOM operation is taking place, the program returns a message that you cannot exit until it finishes handling the DICOM request.

Setting Up DICOM Node Addresses

You must configure DICOM nodes for Application Entities, Brokers, Printers, Local Archives, DICOM Archives, to display in the ***Communications*** window. To list more than one destination for the same person, for example home and office, create two Address Entries.

To set up DICOM node addresses:

1. Click ***New Address*** ☎ on the Communications toolbar. The *Address Entry* Dialog Box opens.



*Compression: Uncompressed

*Address: ● IP ○ DNS

0 . 0 . 0 . 0

☐ Enabled for KODAK ACR Systems

*AE Title:

AE Type: AE

*Port Number: 104

2. Type a value in all fields marked by an asterisk.

Fields

Name

- **Nickname* — Nickname for the addressee, which you type using case-sensitive alphanumeric characters. This is the name is displayed on the Nodes column on the Communications window. If you type a name that is already assigned to another address or if you do not type a name in this field, an error message displays.
- **Compression* — Available compression values for sending images, which you select from a drop-down list. For more information about selecting file compression, see *Compressed Images* on page 43.
- *Last Name* — The last name of the addressee.
- *Title* — The title of the addressee.
- *First Name* — The first name of the addressee.
- *Description* — Comments such as Dr. Smith's home or office.

DICOM Data

- **Address* — Select either the IP or DNS option for the address.

  IP —The Internet Protocol (IP) address for the addressee, which you type in the format: n.n.n.n, where n is any number between 0 and 255.

DNS —The Domain Name System (DNS) is a name-to-IP address service that permits you to use an alphanumeric name instead of a numeric value for an address. Check with your System Administrator to see if this service is available on your network.

- *Enabled for KODAK ACR Systems*– Selecting this box identifies the node as supporting Eastman Kodak Company private DICOM. The image is sent without modifying pixel data in the image when this node is selected. This allows the KODAK ACR Enabled recipient to remove processing or annotations if desired. Images sent to disabled recipients will have their pixel data modified to include processing and annotations that cannot be unprocessed or removed.
- *AE Type* — Categories of application entities, which you select from a drop-down list. You specify an AE (application entity) type to define its function.
- *Printer Type* - This field will only become visible if you select Printer for the AE type. You specify your printer type from a drop-down list. If your printer type is not list, select Generic.
- *Local Archive Directory* — This field will only become visible if you select a Local Archive AE type. The directory path for your local archive that you can create by typing up to 60 alphanumeric characters, excluding characters with ASCII values of 0–31, <, >, “, and |; or by clicking Browse and selecting a directory folder.

AE Types:

AE	Specifies a DICOM address as a node for sending, receiving, querying, and retrieving DICOM images.

AE Types:

DICOM Archive	Identifies a DICOM address as a long-term commitment device for archiving images. This archive must support DICOM storage commitment with a confirmation of delivery. Without confirmation, the archive flag in the Patients window will not switch to "Yes" after a send. When you identify an address as a DICOM archive, an archive icon appears next to the nickname in the Nodes column on the Communications window.
Printer	Identifies a DICOM address as a device for high-resolution DICOM printing. When you identify an address as a DICOM printer, a printer icon appears next to the nickname in the Nodes column on the Communications window.
Broker	Defines a DICOM address as the interface between KODAK General Radiography Software and a hospital/radiology information system (HIS/RIS). When you identify an address as a worklist broker, a broker icon appears next to the nickname in the Nodes column on the Communications window.
Local Archive	Identifies a directory as a location for archiving images. When you identify a directory address as a local archive, an archive icon appears next to the nickname in the Nodes column on the Communications window.

- Click **Save** to save the current entry and return to the Communications window.

  – or –

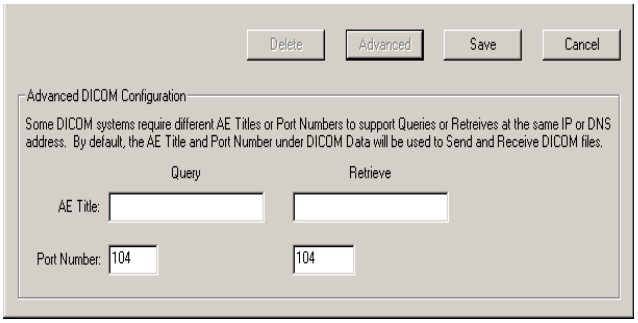
- Click **Cancel** to close the Address Entry dialog box without saving the entry and return to the Communications window.

Advanced Address Entry

Some DICOM systems require different AE Titles or Port Numbers to support Queries or Retrieves at the same IP or DNS address. By default, the AE Title and Port Number under DICOM Data will be used to Send and Receive DICOM files. The Advanced Address Entry dialog box allows you to configure port numbers for sending and receiving DICOM communications.

To access the ***Advanced Address Entry*** dialog box:

1. Click ***New Address*** ☎ on the Communications toolbar. The *Address Entry* Dialog Box opens.
2. Click the **Advanced** button. The ***Advanced Entry*** section is displayed.



Advanced DICOM Configuration

Some DICOM systems require different AE Titles or Port Numbers to support Queries or Retreives at the same IP or DNS address. By default, the AE Title and Port Number under DICOM Data will be used to Send and Receive DICOM files.

	Query	Retrieve
AE Title:		
Port Number:	104	104

- *Query AE Title* — Name of the Application Entity to which KODAK General Radiography Software will direct queries. This value may be up to 16 alphanumeric characters.
- *Query Port Number* — The port number to which KODAK General Radiography Software will direct queries, which you type using a numeric value from 1–65535.

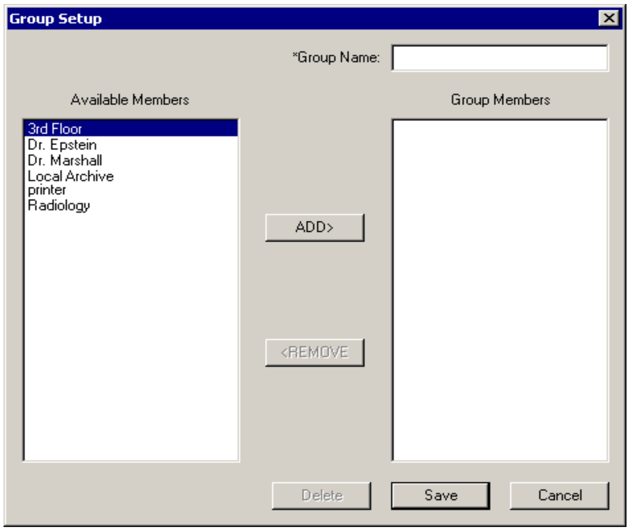
- *Retrieve AE Title* — Name of the Application Entity to which KODAK General Radiography Software will direct retrieves. This value may be up to 16 alphanumeric characters.
- *Retrieve Port Number* — The port number to which KODAK Radiography Software will direct retrieves, which you type using a numeric value from 1–65535.

Creating a Group

Only users with Administrator privileges can edit groups. The ***Group Setup*** window allows you add groups of addresses from your nodes list to a single group name that is displayed on the Nodes list. When you send images to that group name, all members of the group will be sent the selected files.

Groups can only be setup from available address nicknames, and cannot have a worklist broker as a member.

1. Click **New Group** on the ***Communications*** toolbar. The ***Group Setup*** window opens.


Group Setup
*Group Name:
Available Members
Group Members
3rd Floor
Dr. Epstein
Dr. Marshall
Local Archive
printer
Radiology
ADD>
<REMOVE
Delete
Save
Cancel

2. Select group members from the Available Members list. To make multiple selections, hold the **CTRL** key while clicking each item. To select all items in the list, press **CTRL** + A.
3. Click **ADD** to move selected items from the Available Members list to the Group Members list.
4. Click **Remove** to move selected items from the ***Group Members*** list to the ***Available Members*** list.
5. When you are satisfied with the composition of the group, type a Group Name.
6. Do one of the following:
   - Click **Save** or press **ALT-S** to save the current entry and return to the Communications window.

     – or –
   - Click **Cancel** to close the ***Group Setup*** window without saving the entry and return to the ***Communications*** window.

- or -

- Click **Delete** to delete the group, close the ***Group Setup*** window, and return to the ***Communications*** window.

Creating a DICOM Printer

To set up a DICOM printer node:

1. Click ***New Address*** ☎ on the Communications toolbar. The *Address Entry* Dialog Box opens.
2. Type information in the *Name box* fields.
3. Select Printer from the *AE* Type drop-down list in the DICOM Data box.
4. Type the *IP* or *DNS* address, *AE Title,* and *Port Number* for the DICOM Printer.
5. Leave the *Enabled for KODAK ACR Systems* check box unchecked.
6. Select *Printer* from the AE Type drop-down list.
7. Select the manufacturer of the DICOM Printer connected on your network or workstation from the *Printer Type* drop-down list. If the manufacturer is unknown to you, select Generic DICOM Printer.

8. Do one of the following:
   - Click **Save** to save the current entry and return to the ***Communications*** window.

     – or –
   - Click **Cancel** to close the ***Address Entry*** dialog box without saving the entry and return to the Communications window.

Creating a DICOM Archive

1. Click ***New Address*** ☎ on the Communications toolbar. The *Address Entry* Dialog Box opens.
2. Type information in the *Name box* fields. For a list of required fields and descriptions of all Address Entry fields, see *Fields* on page 47.
3. Select Dicom Archive from the *AE* Type drop-down list in the DICOM Data box.
4. Type the *IP* or *DNS* address, *AE Title*, and *Port Number* for the DICOM Archive.
5. Do one of the following:
   - Click **Save** to save the current entry and return to the Communications window.

     – or –
   - Click **Cancel** to close the ***Address Entry*** dialog box without saving the entry and return to the Communications window.

Creating a Local Archive

To create a Local Archive:

1. Click ***New Address*** ☎ on the Communications toolbar. The *Address Entry* Dialog Box opens.
2. Type information in the Name box fields. For a list of required fields and descriptions of all Address Entry fields, see *Fields* on page 47.
3. Select *Local Archive* from the AE Type drop-down list in the

DICOM Data box.

4. Do one of the following:
   - Type the directory path for your local archive (you can use up to 60 characters excluding characters with ASCII values of 0–31, <, >, “, and |).

     – or –
   - Click **Browse** and select a directory folder.
5. Do one of the following:
   - Click **Save** to save the current entry and return to the Communications window.

     – or –
   - Click **Cancel** to close the ***Address Entry*** dialog box without saving the entry and return to the Communications window.

Creating a Worklist Broker

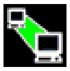
1. Click ***New Address*** ☎ on the Communications toolbar. The *Address Entry* Dialog Box opens.
2. Type information in the Name box fields. For a list of required fields and descriptions of all Address Entry fields, see *Fields* on page 47.
3. Select Broker from the AE Type drop-down list in the DICOM Data box.
4. Type the IP or DNS address, AE Title, and Port Number for the Worklist Broker.
5. Do one of the following:
   - Click **Save** to save the current entry and return to the Communications window.

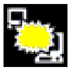
     – or –
   - Click **Cancel** to close the ***Address Entry*** dialog box without saving the entry and return to the Communications window.

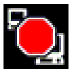
DICOM Request Status

The DICOM Request Status button on the Communications toolbar provides visual information about the status of DICOM requests made by the application.

The button displays in three modes:


Successful communication.


Rescheduling attempts.


One or more attempts have failed.

For more information, see *Appendix B: Troubleshooting* on page 79.

Section 3

Maintaining KODAK General Radiography Software

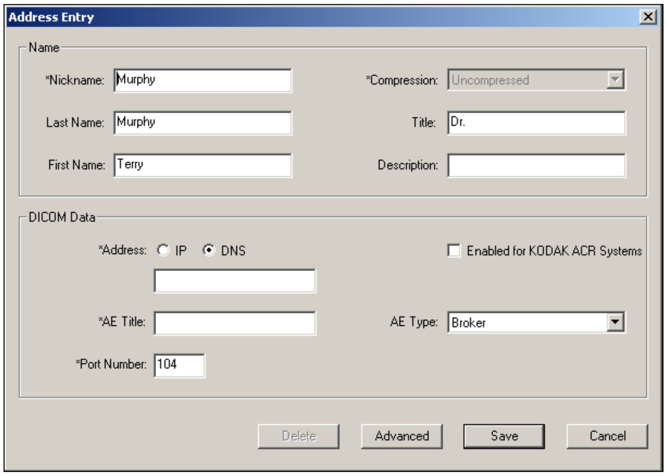
Modifying Nodes

Setting Up Nodes on page 45 explains how to set-up nodes and addresses in the Communications window. This chapter explains how to edit or delete nodes and address information.

Editing Node Addresses

To edit an address:

1. Select an ***Address Nickname*** from the ***Nodes*** list.
2. Right click and select *Edit* from the right-click menu. The ***Address Entry*** dialog box appears for the selected address.



*Nickname: Murphy
Last Name: Murphy
First Name: Terry
*Compression: Uncompressed
Title: Dr.
Description:
*Address: ○ IP ● DNS
*AE Title:
*Port Number: 104
☐ Enabled for KODAK ACR Systems
AE Type: Broker

3. Edit the entries and click Advanced to edit further information. If you edit a Nickname and click Save, a new node is created and the old node is saved. For a list of required fields and descriptions of all Address Entry fields, see *Setting Up Nodes* on page 45.
4. Do one of the following:
   - Click **Save** to save the current entry and return to the Communications window.

     – or –
   - Click **Cancel** to close the Address Entry dialog box without saving the entry and return to the Communications window.

     – or –
   - Click **Delete** to delete the address, close the Address Entry dialog box, and return to the Communications window.

Deleting Node Addresses

There are four ways you can delete an address/node from the Communications window:

Drag-and-Drop

- Select a node/address. Drag the node/address by holding the left mouse button and move the cursor to the Recycle Bin icon. The cursor changes to a hand ✋ when you can drop the address onto the Recycle Bin icon. Release the mouse button.

Right-Click Menu

- Select a node/address and right-click. The right-click menu appears. Scroll to ***Delete***, then click.

  – or –
- Select an node/address and right-click. The right-click menu appears. Scroll to ***Edit***, then click. The ***Address Entry*** dialog box opens, displaying the selected address. Click **Delete** to delete the address. Confirm or cancel your delete action at the prompt.

  – or –
- Select the node/address. Press the Delete key.

Editing Groups

Only users with Administrator privileges can edit groups. You can edit by modifying the group in the Group Window.

1. Select a Group Name from the ***Nodes*** list.
2. Right click and select *Edit* from the right-click menu. The ***Group Setup*** dialog box appears for the selected address.
3. Edit the information.
4. Do one of the following:
   - Click **Save** to save the current entry and return to the Communications window.

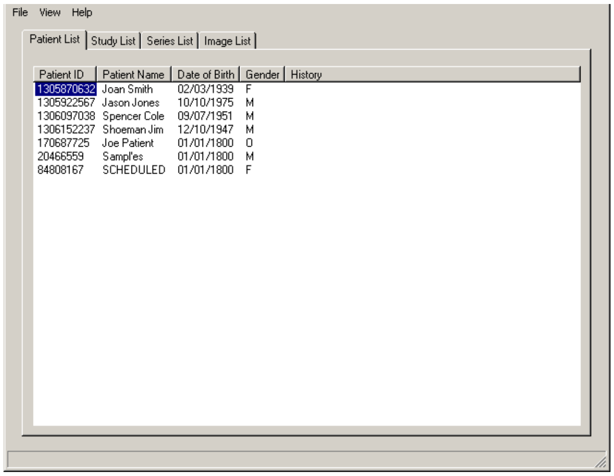
     – or –
   - Click **Cancel** to close the ***Group Setup*** dialog box without saving the entry and return to the Communications window.

     – or –
   - Click **Delete** to delete the address, close the ***Group Setup***

dialog box, and return to the Communications window.

Using the Database Utility

The database utility allows you to browse the contents of your local image database and check the stored images against your patient list. The database utility follows the DICOM sorting order — Patient, Study, Series, Image.



Patient ID	Patient Name	Date of Birth	Gender	History
1305870632	Joan Smith	02/03/1939	F	
1305922567	Jason Jones	10/10/1975	M	
1306097038	Spencer Cole	09/07/1951	M	
1306152237	Shoeman Jim	12/10/1947	M	
170687725	Joe Patient	01/01/1800	O	
20466559	Sampl'es	01/01/1800	M	
84808167	SCHEDULED	01/01/1800	F	

Running the Database Utility

To run the database utility, you must quit KODAK General Radiography Software before you can run dbutil.exe, located in the DI-3000 directory.

Database Tab: Patient List

- To follow a patient through the storage hierarchy select a Patient ID in the ***Patient List*** tab.

Database Tab: Image List

- To show the images listed under the selected series click the ***Image List*** tab.

Database Tab: Series List

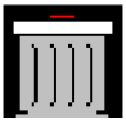
- To show the series listed under the selected study click the ***Series List*** tab.

Database Tab: Study List

- To show the studies listed under the selected patient click the ***Study List*** tab.

Before you can run KODAK General Radiography Software, you must quit the database utility.

Deleting Images



The *Recycle Bin*—the trash can icon located on the lower left-corner of the ***Communications*** panel of the Main Application window—permits you to delete and restore unarchived images to the Main Application window.

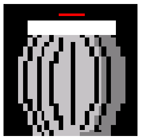
There are two ways to open the ***Recycle Bin window***:

- Double-click the trash can icon
- Select Start>Programs>Eastman Kodak Company>Recycle Bin

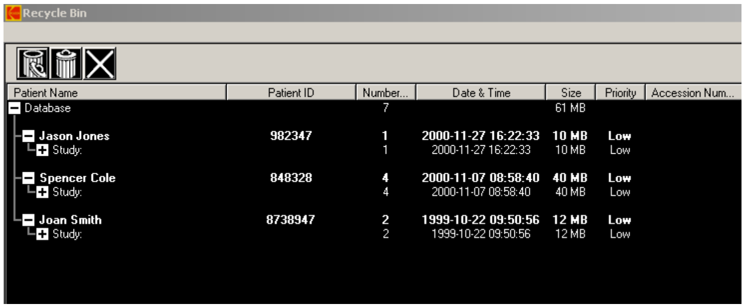
The recover unarchived image functionality is only available to users of KODAK General Radiography Software with an attached ACR-2000 scanner. All images on a system with a film scanner, when deleted, are permanently deleted.

Note: *Archived images dragged to the Recycle Bin cannot be restored.*

When unarchived images are in the *Recycle Bin*, the trash can will appear inflated.



Recycle Bin Window

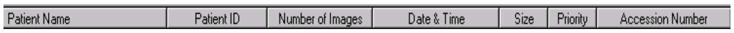


Patient Name	Patient ID	Number...	Date & Time	Size	Priority	Accession Num...
Database		7		61 MB		
Jason Jones	**982347**	**1**	**2000-11-27 16:22:33**	**10 MB**	**Low**	
Study:		1	2000-11-27 16:22:33	10 MB	Low	
Spencer Cole	**848328**	**4**	**2000-11-07 08:58:40**	**40 MB**	**Low**	
Study:		4	2000-11-07 08:58:40	40 MB	Low	
Joan Smith	**8738947**	**2**	**1999-10-22 09:50:56**	**12 MB**	**Low**	
Study:		2	1999-10-22 09:50:56	12 MB	Low	

The ***Recycle Bin window*** displays patient information in the DICOM hierarchy format: Patient, Study, Series, Image. Each level displays the information appropriate to that level.

You can display or hide a level by clicking the + or - above that level. The entire list can be expanded by clicking the database level.

The Recycle Bin window displays Patient demographic information in the following sortable columns:



Patient Name	Patient ID	Number of Images	Date & Time	Size	Priority	Accession Number

- **Patient Name**

  Name of the Patient.
- **Patient ID**

  Identification number assigned to the Patient.
- **Number of Images**

  Total number of images in the Patient, Study, and Series levels.
- **Date & Time**

  Date and Time the study was created in the application.
- **Size**

  Size in kilobytes (KB) or megabytes (MB) of the Patient, Study, Series and Image files or levels. The total size at the Patient level may not equal the sum of the Study, Series, and Image levels due to rounding.

- **Priority**

  Stat, Regular, Low. The Patient level displays the priority of the highest priority series.
- **Accession Number**

  Patient visit identification number.

Restoring Images From the Recycle Bin

1. Select a **Patient**, **Study**, **Series**, or **Image** from the displayed list that you want to restore. Click on an item to select it, or to make multiple selections, hold the control key while clicking each item.
2. Click **Restore** . The selected items will be restored to the *Patients window.*

Note: *This option will only be available when an item has been selected to restore.*

Permanently Deleting Images From the Recycle Bin

Note: *This option is only available to administrators.*

1. Select the unarchived **Patients**, **Studies**, **Series**, or **Images** from the displayed list that you want to permanently delete. Click on an item to select it, or to make multiple selections, hold the control key while clicking each item.
2. Click **Delete** .

Note: *CR Images should* **always** *be archived before being permanently deleted.*

Closing the Recycle Bin

- Click **Exit** to close the ***Recycle Bin*** window.

Log Files

All DICOM, database, file transmission, archive, printer operation, modality worklist, and scanner operation events are recorded in log files. For explanations of Log Messages, see *Appendix A: Log Messages* on page 71.

Accessing Log Files

To access log files, open:

- EVENTS.LOG — Displays DICOM, database, file transmission, DICOM archive, modality worklist, and scanner activities.
- HISTORY.TXT — Displays scanner self-test activity.

Appendix A: Log Messages

Messages in the Log File are displayed in one of the following formats:

General Functions: * Date * Time * Function * Synopsis **
DICOM Functions: * Date * Time * DICOM * DICOM Function (xx) – Synopsis **

Function/Synopsis	Explanation/Cause/Remedy
Function: * DELETIONS *	
Patient ID = (Patient ID), Patient Name (Patient Name)	Patient identified by (Patient Name), (Patient ID) was deleted.
Delete Address Book Entry (Nickname (Nickname))	(Nickname) was deleted from the Address Book.
Function: * DICOM ARCHIVE *	
Patient ID: (Patient ID) Study ID: (Study UID) Image UID: (Image UID) has been archived successfully.	(Image UID) has been successfully archived.
Patient ID: Study ID: Image UID: (Image UID) has failed DICOM Archive verification.	(Image UID) could not be verified as successfully archived. The DICOM Archive the image was sent to does not support DICOM Storage Commit. The image was NOT marked as archived in KODAK General Radiography Software. Refer to the DICOM Archive User Manual or Technical Support.
Function: * IMAGE MOVED *	

Function/Synopsis	Explanation/Cause/Remedy
Patient Name: (Patient Name 1), Patient ID: (Patient ID 1) to Patient Name: (Patient Name 2), Patient ID: (Patient ID 2) - (Image UID)	Image (Image UID) has been moved from (Patient Name 1) and (Patient ID 1) to (Patient Name 2) and (Patient ID 2).
Function: * MODALITY WORKLIST *	
Study UID: '(Study UID)' overwritten with modality worklist import	Current user chose to overwrite (Study UID) with a new entry from a DICOM Worklist Broker.
Patient ID: '(Patient ID)', overwritten with modality worklist import	Current user chose to overwrite (Patient ID) with a new entry from a DICOM Worklist Broker.
Function: * SCANNING *	
Scan Started.	Film or plate scan has been started by the user.
Scan Finished, Image acquired Successfully.	Film or plate scan has been successfully scanned by the user.
WARNING -- Scan Finished, Image acquisition failed!.	Film or plate failed to scan properly. Check the scanning hardware, reboot the system and retry the scan. If the problem persists, contact Technical Support.
Function: * SECURITY *	
Logon successful.	KODAK General Radiography Software started successfully.
Patient Name: (Patient Name 1) and Patient ID: (Patient ID 1) have been changed to Patient Name: (Patient Name 2) and Patient ID: (Patient ID 2).	Patient Information has been edited from (Patient Name 1) and (Patient ID 1) to (Patient Name 2) and (Patient ID 2) by the user.
Function: * SYSTEMS *	
Unable to store DICOM file. Out of Disk space!!	Not enough disk space to write the DICOM file. Free some disk space and reboot the system.

Function/Synopsis	Explanation/Cause/Remedy
Function: * DICOM *	
Incoming Connection	Remote AE successfully connected to the local station.
DICOM is available at (AE Title)	(AE Title) has a DICOM program running.
File received that is not DICOM 3.0 compliant. File (Filename) was not entered into the database.	(Filename) received was non-DICOM 3.0 compliant and was rejected. No entry was made in the local database.
Duplicate file received that is already in the database. File (Filename) was not entered into the database and was deleted from disk	(Filename) received was already in the local database and was rejected. No entry was made in the local database.
Unable to store DICOM file. Out of Disk space!!	Not enough disk space to write the DICOM file. Free some disk space and reboot the system.
Function: * DICOM * CEcho -	
Trying to Connect – (AE Title) at (IP):(Port)	Starting a DICOM Checksite to (AE Title).
Connected – (AE Title) at (IP):(Port)	DICOM Checksite to (AE Title) succeeded.
Unable to Connect – (AE Title) at (IP):(Port)	DICOM Checksite to (AE Title) failed. Check that the DICOM information is properly entered in both local and remote address books. Check that the networking (hardware and software) is properly setup on both machines (using *ping* for example). If the problem persists, contact your Network Administrator.
Function: * DICOM * CMove -	
Trying to Connect – (AE Title) at (IP):(Port)	Starting a DICOM Q/R to (AE Title).
Connected – (AE Title) at (IP):(Port)	DICOM Q/R to (AE Title) initiated.
Function: * DICOM * CStore -	

Function/Synopsis	Explanation/Cause/Remedy
Send Succeeded – (Patient Name) (Filename) to (AE Title) at (IP)	(Filename) from patient (Patient Name) successfully sent to (AE Title).
Sending Done – (AE Title) at (IP)	DICOM Sending of images to (AE Title) has been completed.
Failed – Unable to Open File – (Filename)	(Filename) does not exist on the disk. The image does not exist on disk and needs to be brought back from a remote or local archive.
Connection Rejected to (AE Title)	DICOM connection rejected by (AE Title). The remote DICOM station does not accept this type of image. Refer to the remote DICOM station User Manual or Technical Support.
Rescheduling Request	DICOM Sending of images could not be completed at this time and will be attempted again in a few minutes.
Function: * DICOM * Mod Wrk Lst -	
Trying to Connect – (AE Title) at (IP):(Port)	Starting a DICOM Worklist Broker Q/R to (AE Title).
Connected – (AE Title) at (IP):(Port)	DICOM Worklist Broker Q/R to (AE Title) initiated.
Unable to Connect – (AE Title) at (IP):(Port)	DICOM Worklist Broker query to (AE Title) failed. Check that the DICOM information is properly entered in both local and Broker address books. Check that the networking (hardware and software) is properly setup on both machines (for example, using *ping*) If the problem persists, contact your Network Administrator.
Modality Worklist failed.	Modality worklist query or retrieve failed for unspecified reasons.

Function/Synopsis	Explanation/Cause/Remedy
Modality Worklist query unable to initialize TCP.	Modality worklist query unable to initialize the TCP stack. Check the network settings and reboot the system.
Modality Worklist query unable to initialize Service Class.	Modality worklist query unable to initialize a service class. Contact Technical Support for further assistance.
Modality Worklist query rejected due to invalid calling AE Title (AE Title).	Modality worklist query rejected because of an invalid calling AE Title. (AE Title) is the invalid local station. Refer to the DICOM Worklist Broker User Manual or Technical Support.
Modality Worklist query rejected due to invalid called AE Title (AE Title).	Modality worklist query rejected because of an invalid called AE Title. (AE Title) is the invalid remote called AE Title. Refer to the DICOM Worklist Broker User Manual or Technical Support.
Modality Worklist broker rejected query due to congested network traffic.	Modality worklist query was rejected due to bandwidth restrictions on the network. Check your network hardware and contact your Network Administrator.
Modality Worklist broker received incorrect string match.	The modality worklist broker received an incorrect string match from the local station. Contact Technical Support for further assistance.
Modality Worklist query cancelled.	Modality worklist query cancelled by either the user or the worklist broker.
Modality Worklist invalid parameters.	Modality worklist query with invalid parameters. Contact Technical Support for further assistance.
Modality Worklist rejected.	Modality worklist query or retrieve rejected by the worklist broker for unspecified reasons. Refer to the DICOM Worklist Broker User Manual or Technical Support.

Function/Synopsis	Explanation/Cause/Remedy
Modality Worklist rejected. Protocol not supported.	Modality worklist query or retrieve rejected due to an unsupported protocol. Refer to the DICOM Worklist Broker User Manual or Technical Support.
Modality Worklist rejected. Application context name is not supported.	Modality worklist query or retrieve rejected due to an unsupported application context name. Refer to the DICOM Worklist Broker User Manual or Technical Support.
Modality Worklist rejected. Local limit exceeded.	Modality worklist query or retrieve rejected because the local limit was exceeded. Refer to the DICOM Worklist Broker User Manual or Technical Support.
Modality Worklist refused. Out of resources.	Modality worklist query or retrieve refused because of a lack of worklist broker resources. Refer to the DICOM Worklist Broker User Manual or Technical Support.
Modality Worklist failed. Identifier error.	Modality worklist query or retrieve failed due to an identifier error. Refer to the DICOM Worklist Broker User Manual or Technical Support.
Function: * DICOM * Mod Wrk Lst PPS -	
Failed – Abstract Syntax Not Supported – (AE Title) at (IP):(Port)	DICOM Worklist Broker (AE Title) does not support DICOM Performed Procedure Step (PPS). Refer to the DICOM Worklist Broker User Manual or Technical Support.
Unable to Connect – (AE Title) at (IP):(Port)	DICOM Worklist Broker PPS to (AE Title) failed. Refer to the DICOM Worklist Broker User Manual or Technical Support.
Function: * DICOM * Part10 -	
Copying Image – (Filename)	(Filename) has been copied to a local archive.

Function/Synopsis	Explanation/Cause/Remedy
Function: * DICOM * Provider -	
Start Listen Success -	Local DICOM provider successfully started.
Stop Listen Success -	Local DICOM provider successfully stopped.
TCP ERROR -	TCP problem with the local station. Check the networking information and reboot the system.
Start Listen Failed -	Local DICOM provider could not start. DICOM images cannot be received by the local station. Reboot the system.
Stop Listen Failed -	Local DICOM provider could not stop. Wait until all DICOM communications have stopped and try again. If this problem persists, reboot the system.
Association Connected – (AE Title) at (IP):(Port)	Incoming DICOM association from (AE Title).
Verify Remote Site – (AE Title) at (IP)	Local station checking (AE Title) in the local address book.
Association Ended – (AE Title) at (IP):(Port)	The DICOM association from (AE Title) completed.
Invalid Calling AE Title – (AE Title) at (IP)	Remote DICOM station (AE Title) not in the local address book. Add (AE Title) to the local address book to allow communications from (AE Title).
End Handling Cstore Request <FAILURE>	DICOM file was not received properly. Resend the file.
Function: * DICOM * Unknown -	
Failed – Unable to Open File – (Filename)	(Filename) does not exist on the disk. The image does not exist on disk and needs to be resent.

Function/Synopsis	Explanation/Cause/Remedy
Failed – Invalid File – (Filename)	(Filename) is not a valid DICOM file. The image does not follow the DICOM 3.0 standard. Refer to the sending station User Manual or Technical Support.

Appendix B: Troubleshooting

Possible Problem	Resolution/Explanation
Jammed film or plate	Ensure the scanner motor has stopped. If necessary, at the scanner, press Scan Abort. If the jam does not clear, refer to Section 3.0 System Operation of the Lumiscan LSDT Service Manual. If the jam still does not clear, call your certified service provider. Note: If you turn off and on the scanner you must wait at least five minutes before scanning.
Image Files Sent with Incorrect Compression	You can send images to other DICOM nodes in compressed or uncompressed formats. If an addressee is setup to receive lossy compression, a yellow triangle appears next to the nickname on the Communications Window.
Image Processing Failure	If a Image Processing Warning appears, contact your system administrator, or, CR system representative if you are an administrator, describe the failure and give them the name of the selected process that failed and the accompanying error code.
Improper Image Acquisition: Host PC Too Busy	To ensure adequate system performance, an administrator must configure your system with the minimum hardware and software as specified in the Hardware Compatibility List furnished with KODAK General Radiography Software.

Possible Problem	Resolution/Explanation
Improper Image Orientation	Review each scanned image and, as necessary, use the following functions to orient the image properly. Flip Vertical - Click this button to flip an active image vertically. Flip Horizontal - Click this button to flip an active image horizontally. Rotate Left - Click this button to rotate an active image 90^o left. Rotate Right - Click this button to rotate an active image 90^o right.
Unable To Store Images	Ensure that your image directory resides on your local hard drive to avoid the inability to access images in the event of network failure.
Incomplete image acquisition due to improper data control board (DCB) settings	Scanner DCBs have on-board RAM that temporarily stores the scanned image before KODAK General Radiography Software retrieves it. Your certified service provider must validate the DCB settings after KODAK General Radiography Software installation as well as after installation or upgrade of the DCB.
Images Sent to Wrong Destination	Ensure the target computer’ s address with the corresponding Send/Receive AE Title and Port Number is entered on the Address Entry Dialog Box. Ensure the sender’ s address is in the target computer’ s Address Book. Drag the correct image(s) from the Patient list and drop it into the address in the Communications Window.
Transmission failure	Open the events log to view which DICOM node failed transmission. See *Log Files* on page 69. Perform a *Check Site* to ensure the remote site is available for receiving images. If the remote site is not available, contact the remote site personnel to determine availability.
Repeated transmission failure	Ensure that you are using a unique patient ID when sending to another DICOM node. Contact the remote site personnel to determine if they are having a database conflict due to duplicate file information.

Possible Problem	Resolution/Explanation
Repeated transmission failure to a specific destination	If you are experiencing repeated transmission failure to a specific destination: 1) Perform a *Check Site* to determine the DICOM availability of the remote location. 2) Contact the remote site personnel and verify they have your workstation’s IP or DNS address, AE Title, and Port Number in their local address book and that they permit the type of DICOM operation you are attempting.
Communications Window Toolbar displays: ***Rescheduling attempts*** 🟡 ***One or more attempts have failed*** 🛑	Click the DICOM Request Status button to display the DICOM Request Status window and do one of the following: • Wait for the system to reattempt the request • Clear the Request • Reprocess the request 1) From the DICOM Request Status Window, select the request from the list. To make multiple selections, hold the **CTRL** key while clicking each item. 3) Click one of the following buttons: • **Clear All Requests** —clears all pending requests • **Clear Request** —clears the request • **Reprocess Request** to reprocess the selected requests

Appendix C: Warnings

The following warnings are intended to prevent any potential patient or operator safety hazards. Please read them carefully.

WARNING
It is highly recommended that you • Periodically perform preventive maintenance of your local hard drive(s) using Windows 2000 Administrative Tools to reduce the chances of disk crashes. • Frequently archive all data on your hard disk to avoid data loss in the event of a hard disk crash. • Periodically check your local storage device(s) and media for defects to reduce the chances of data corruption.
The DICOM and Windows printing capability is intended for reference only and not for diagnosis.
The technician must ensure proper orientation of the image prior to saving or sending. The diagnosing physician must make sure the scanned image is oriented properly before making a diagnosis.
The Read/Unread feature is intended to be used only by the diagnosing physician. Use care when marking images with Read/Unread.
Run the Self-Test regularly to ensure acceptable ACR-2000 performance.
Stopping the scanner or pressing the Scan Abort button results in lost CR plate content and may result in an improper image acquisition or a lost image.
Images scanned on the ACR-2000 scanner at 1K (1024 pixels/line) or lower resolution may not be of diagnostic quality.
Jammed films or plates could cause improper image acquisition.
If you manipulate or process images while synchronization is on, images could be affected that are currently not being viewed on the screen.

WARNING
Ensure the correct match has been found for the Accession number while using the Scan Wizard; otherwise, you could have the incorrect patient information.
The displayed image (during the Scan Wizard) is intended for ensuring correct image orientation and not for diagnosis.
Annotations/measurements are for reference only and are not intended for diagnostic use.
Image processing applied to images not acquired with an ACR-2000 may result in non-diagnostic quality images.
Improper equipment operation may result in injury to personnel due to the laser. All CR and digitizer users must be trained in the proper operation of equipment by certified service providers.
Improper installation, hardware configuration, and maintenance could result in improper image acquisition or lost images.
KODAK General Radiography Software is optimized to run across local area networks (LANs). If sending patient records to your selected destination requires the use of a wide area network (WAN), you may experience transmission difficulty due to the inherent unreliability of WANs. You should contact the remote site to verify they received the expected patient records and resend if necessary.
All images must have patient identification burned into the image at the time the x-ray is taken.
KODAK General Radiography Software is not intended to be used for primary diagnosis of received images.
When an image with processing or annotations is sent, the image pixel data is modified to include any processing and annotations. Once the image is received at the remote station, the processing and annotations cannot be removed from the image.
When an image with processing or annotations is retrieved, the image is provided without including either the processing or the annotations.
Configure the monitor for square pixels; otherwise, the image aspect ratio could be incorrect.
Lossy-compressed images may not be of diagnostic quality. Compressed files take less time to transmit, but lossy compressed files result in data loss and lower image quality.

http://www.kodak.com/go/health (800) 328-2910

KODAK General Radiography Software

User Reference Guide

Health Imaging

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KODAK General Radiography Software User Reference Guide
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Electronic Radiology Laboratory
Mallinckrodt Institute of Radiology
Washington University School of Medicine
510 S. Kingshighway Blvd.
St. Louis, MO 63110

as part of the 1993–1995 DICOM Central Test Node project for, and under contract with, the Radiological Society of North America.

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Introduction

About KODAK General Radiography Software

KODAK General Radiography Software, running on Microsoft Windows 2000 Professional operating system, digitizes computed radiography (CR) plates—using only the ACR-2000 desktop scanner—or radiology films using one of the LS series of desktop scanners. The scanned image files are DICOM 3.0-compliant. You can set up the software to perform DICOM operations of sending, querying, retrieving, printing, and archiving image files over a local area network (LAN) or wide area network (WAN) to other DICOM nodes.

You can use KODAK General Radiography Software to:

- Scan CR plates or radiology films and produce digitized images for use with a primary diagnostic viewing station
- View and manipulate images in thumbnail and full-sizes
- Annotate images
- Create Patient and Study information to attach to images
- Apply image processing and window/level capabilities to images
- Send images to other DICOM nodes in compressed or uncompressed formats
- Print images to a Windows printer or DICOM printer
- Perform quality assurance self-test functions
- Use the drag-and-drop feature to move images in the Patient list
- Query a modality worklist broker to download worklist information about scheduled procedures and related patient demographic data.

- Query and Retrieve to and from other DICOM nodes
- Archive and Retrieve patient records to and from a local or DICOM archive
- Restore unarchived CR images, as well as permanently delete unarchived CR images, from the Recycle Bin

Starting and Quitting KODAK General Radiography Software

Starting KODAK General Radiography Software

- Click **Start,** scroll to *Programs, Eastman Kodak Company,* then click KODAK General Radiography Software. The ***Application Main Window*** opens.

Quitting KODAK General Radiography Software

You cannot quit KODAK General Radiography Software while DICOM operations are in progress. If you attempt to quit the program during a DICOM operation, the program displays a message that you cannot exit until the DICOM request is complete.

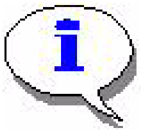
- To quit, click the **X** in the upper right corner of the window.

Message Box Symbols

A message box conveys information about a particular situation or condition.

Note: Always read Message boxes thoroughly for proper operation of the scanning software.

Message boxes in the scanning software include a graphical symbol that indicates what kind of message is being presented. The following symbols are included in the scanning software message boxes:



- **Information** — Provides you information about the results of a command.

- ❓ **Question** — Provides a message that requires you to answer a question about a command.
- ⚠ **Warning** — Alerts you to a condition or situation that requires your decision and input before proceeding; such as an impending action with potentially destructive, irreversible consequences.
- ❌ **Critical** — Informs you of a serious problem that requires intervention or correction before work can continue.

What Is DICOM 3.0?

KODAK General Radiography Software creates Digital Imaging and Communications in Medicine (DICOM) 3.0-compliant images. The DICOM standard defines formatting, storage, and transmission protocols for digital images. These protocols allow medical images and the clinical information associated with those images to be captured, transferred, viewed, and manipulated with DICOM-compatible hardware and software. The DICOM standard defines a storage hierarchy of Patient, Study, Series, and Image.

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Eastman Kodak Company does not assume responsibility, nor shall it be held responsible for tort liability of the customer with respect to any claims of the customer's patients relating to patient care issues. The parties recognize and understand that data is generated through the scanning of CR plates or radiology film and it is to be used with a primary diagnostic viewing station.

The image quality for display using the software is dependent on the hardware configuration and the transmission architecture chosen and may not be of primary diagnostic quality in all cases. Eastman Kodak Company assumes no responsibility for the quality of displayed image data.

All manipulation processes are designed for images acquired with Eastman Kodak Company ACR systems. All other types of images may produce unexpected results.

Printing too many large images may result in printer malfunction.

Scanning Setup

Hardware Setup

WARNING: Improper equipment operation may result in injury to personnel due to the laser. All CR and digitizer users must be trained in the proper operation of equipment by certified service providers. Improper installation, hardware configuration, and maintenance could result in improper image acquisition and therefore improper diagnosis.

To optimize system performance, ensure you:

- Use only approved hardware specified in the *Hardware Compatibility List* found in the KODAK General Radiography Software distribution package.
- Follow the workstation and Eastman Kodak Company hardware configuration and set-up instructions.
- Follow the workstation and Eastman Kodak Company hardware guidelines for periodic system maintenance. For complete information on Eastman Kodak Company digitizer operations, see the *LSDT Service Manual* or for CR scanning operations, see the *ACR-2000 Service Manual*.
- Periodically perform preventive maintenance of your local hard drive(s) using Windows 2000 Administrative Tools.

Note: Before beginning a scanning session, ensure the scanner is on and warmed up for five minutes.

Managing Disk Space

At program startup and at the beginning of each scan operation, the application reads the available space on the drive where the directory for images is located, then permits you to scan CR plates or radiology film if there is enough space. If there is not enough space, a message advises you to free up disk space. When this message occurs, the program completes any scanning operation in progress, and does not allow any more scans until disk space is available. You can free up disk space by deleting patient records.

For information on archiving to free up disk space, see *Archiving Images* on page 65.

Performing the ACR-2000 Self-Test

● CR Only

WARNING: Run the Self-Test regularly to ensure acceptable ACR-2000 performance.

At application startup and at any time you click **Self-Test** ● (found on the Patients toolbar), the program performs a quality assurance self-test to verify that the ACR-2000 meets acceptable performance standards. Be sure you perform the self-test function at least once per day.

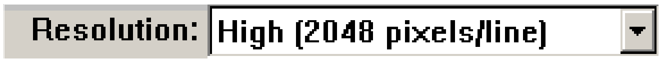
Note: Image quality and self-test results are affected by ambient light.

The self-test function creates output files that report the overall status of the ACR-2000 on the basis of the self-test results. You can view results of the self-test functions via:

- Status Window
- Printed Test Report

Resolution

Before beginning a scanning session, you can change the resolution at which to scan CR plates or radiology film on the ***Preview*** window toolbar.



High (2048 pixels/line)

- On the ***Preview*** window toolbar, from the **Resolution** drop-down list, select the scanning resolution at which you want to scan a CR plate or radiology film.

WARNING: Images scanned on the ACR-2000 scanner at 1K (1024 pixels/line) or lower resolution may not be of diagnostic quality.

Scanning

WARNING: All images must have patient identification burned into the image at the time the x-ray is taken.

Note: While scanning is in progress, you cannot view or send images.

Specifying Image Assignment

Before you scan CR plates or single films, you must select a Patient, Study, or Series. For Scanning Multiple Films, the Database line or Unassigned Images line should be selected.

Scanning a Single CR Plate

CR Only

1. On the ***Patients*** window, select a Patient or Study, to which you want to assign the image.
2. Darken the room, take the CR plate out of the cassette, and position the CR plate on the feed slot of the scanner with the exposed side of the CR plate facing the feed guide.
3. Click **Scan** on the ***Preview*** window toolbar. The Image Setup Window is displayed.
4. Select a **Body Part**, **Projection** and **Grid Removal** option.
5. Click **Scan**. The CR plate is scanned and advances to the exit tray and a thumbnail image appears in the ***Preview*** window.

Scanning a Single Film

Digitizer Only

1. Ensure the **READY** light is on.

Note: A blinking READY light indicates the scanner has not been reset.

2. At a scanner with a **single-sheet feeder**, center the film in the slot top down, left edge on the left side.
3. On the **Patients** window, select a Patient or Study, (or the DICOM Database or Unassigned Images line) to which you want to assign the image.
4. Click **Scan** on the Preview window toolbar.
5. The film is scanned and advances to the film output area and a thumbnail image appears in the ***Preview*** window.

Scanning Multiple Films

Digitizer Only

You can scan films in a batch.

Loading the Film Feeder

Load films in the following way to produce the proper orientation for viewing the scanned images.

Bulk Film Loader

- Insert films in the bulk film loader with the top of the film down, left edge on the left side, with the film loaded to the left side of the bulk loader.

Six-Sheet Film Feeder

- Insert films in the six-sheet film feeder left edge on the left side, with the film centered in the film feeder.

Film Feeder/Bulk Loader Batch Scanning

1. Press the film feeder **Reset** lever if you are using the 6-sheet feeder. Ensure the **READY** light is on.

Note: A blinking READY light indicates the scanner has not been reset. If you attempt to scan multiple films with a six-sheet feeder before resetting the scanner, a jam will occur.

2. At a scanner with a **six-sheet feeder**, center the first film in slot 1 top down, left edge on the left side. Continue loading until all six slots are filled.
3. At a scanner with **a bulk film loader**, load all films to the left side of the bulk film loader. Film sizes and orientations may be mixed in the bulk film loader as long as no film is more than 14-inches wide.
4. From the ***Patients*** window, select:
   - the Patient, Study, or Series to which you want to scan an image

   – or –

   - the Database Line

   – or –

   - if available, select the Unassigned Images folder.
5. Click **Scan** from the **Preview** window toolbar. The films are scanned and advance to the output area and thumbnail images appear in the ***Preview*** window.

Scan Wizard

CR Only

1. Darken the room, take the CR plate out of the cassette, and position the CR plate on the feed slot of the scanner with the exposed side of the CR plate facing the feed guide.
2. Click **Scan Wizard**. The **Select Patient** dialog appears.
3. Enter the **Accession Number** for the patient and click **Search**. The program searches for the patient information from the Broker(s) in your address book.

   One of the following occurs.

   - If a match is found, the ***Image Setup*** window displays. Go to step 4.

WARNING: Ensure the correct match has been found for the Accession number while using the Scan Wizard; otherwise, you could have the incorrect patient information.

- If no match is found in the Broker(s), a message states that the patient information is not found and suggests you Create a New Patient.
- If multiple patients have the same accession number, a warning appears. Query the broker from the **Main Application** window and scan the image from there.
- If no Broker(s) is in your address book, the **Select Patient** dialog box displays. Click **Create Patient**.
- In the **Image Setup** window, if the patient information is incorrect, click **Select Patient**, and enter a different **Accession Number**.

4. If the patient information is correct, select a **Body Part**, **Projection** and **Grid Removal** option.
5. Click **Scan**. The **Send/Review** window is displayed.

Warning: The displayed image is intended for ensuring correct image orientation and not for diagnosis.

---

6. From the **Send/Review** window, you can view a full screen of the image by clicking **View Full Screen Image,** then click **X** in the Image Display window to return to the **Send/Review** window.
7. Manipulate the image by using the Flip and Rotate and Undo functions, and click **Save**💾 to save any changes.
8. To print, send, or archive the scan, select the **Destination** from the drop-down list and click **Send**.
9. You can scan a new image, by clicking **New Scan** and return to the **Image Setup** window or to add a new patient, click **New Patient**.
10. To cancel, click **Quit**.

Stopping the Scanner

CAUTION: **All scanner users must be trained in the proper operation of equipment by certified service providers. Keep all loose or hanging objects, such as clothing, hair, and jewelry, away from the scanner feed slot. Failure to comply may result in injury to personnel or damage to equipment.**

WARNING**: Stopping the scanner or pressing the Scan Abort button results in lost CR plate content and may result in an improper image acquisition or a lost image.**

For personnel safety reasons, you can stop a scanner:

- At the scanner, press **Scan Abort.** The scanner motor stops and the scanning operation ceases.
- To clear a CR plate or sheet of film from the scanner, press **Scan Abort** again to reverse the motor feed direction.
- To stop the motor, press **Scan Abort** one more time.

Main Application Window

You access all program functions through the ***Main Application*** window. The main window contains three scalable window panes, with their associated toolbars, a status bar, and a Recycle Bin.

Window Resizing

You can resize the windows by clicking on the dividing line between the windows and dragging.

Toolbars

Toolbars display buttons and commands for each window pane.

Status Bar

The status bar is located at the bottom of the ***Main Application*** window. The Status Bar displays the status of file transmissions, the file currently being transmitted to another DICOM node, and the make and model of the attached scanner.

Recycle Bin

You can delete Patients, Studies, Series, and Images by dragging them from the Patients and Preview window and dropping them into the Recycle Bin icon located on the lower-left corner of the

Main Application window**.** For more information see *Deleting Images from the Preview Window* on page 19 and *Deleting Images* on page 69.

Communications Window

The *Communications* window is used for creating and managing address entries, establishing communications with other DICOM nodes, querying a modality worklist broker, archiving (both locally and to a DICOM archive), and printing to a high-resolution DICOM printer.

Patients window

The Patients window is used for creating and managing the Patients list, entering patient/study information associated with each image in the database; performing quality assurance self-test functions (CR only); activating the Scan Wizard (CR only), changing the font sizes, and viewing, manipulating, processing, and printing (Windows printers only) images via the **Image Display** window. For more information, see *Patients* on page 21.

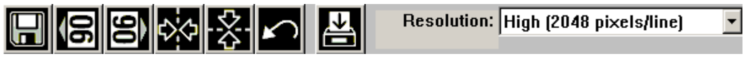
Preview Window and Toolbar

The ***Preview*** window displays thumbnails of scanned images. You can use the scroll bar at right to view thumbnail images when there are more than can fit on the window.

From the ***Preview*** window, you can:

- Start scanning operations
- Select scanning resolution
- Manipulate thumbnails of scanned images
- Save manipulations to thumbnails
- Use the drag-and-drop feature to move images to the Recycle Bin

Preview Toolbar



Resolution: High (2048 pixels/line)

You can manipulate image display settings and some scanning settings from this toolbar. When you click a button, the setting for that function is applied.

Save

Click **Save** to save any image manipulations you applied to an active image.

Flip and Rotate Functions

The toolbar has two flip and two rotate functions that you use to ensure proper orientation of the image prior to saving or sending:

Flip Vertical

Click this button to flip an active image vertically.

Flip Horizontal

Click this button to flip an active image horizontally.

Rotate Left

Click this button to rotate an active image 90 ^{o} left.

Rotate Right

Click this button to rotate an active image 90 ^{o} right.

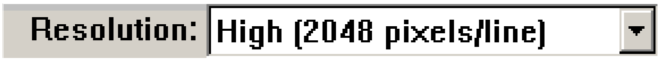
Undo

Click **Undo** to revert all image manipulations you applied to an active image to the last saved version of the image.

Scan

Click **Scan** or press **F12** to start the scanning operation.

Resolution



Resolution: High (2048 pixels/line)

From the **Resolution** drop-down list, select the resolution at which you want to scan the CR plate or radiology film.

Warning: Images scanned on the ACR-2000 scanner at 1K (1024 pixels/line) or lower resolution may not be of diagnostic quality.

Image Markings

KODAK General Radiography Software marks thumbnail images to show you the status of the image. There are two marks used:

- Image Number — Thumbnail images display in the order scanned and are marked with a number in the lower-left corner of the image.
- Selection — When you select a thumbnail image to view, manipulate, or drag to the Recycle Bin, an *X* appears in the lower-right corner of the image to indicate an active image.

Manipulating Thumbnail Images

You can change thumbnail image orientation and save or undo the results from the ***Preview*** window toolbar. The right-click menu enables the same functions in addition to displaying or deleting the image from the database.

Deleting Images from the Preview Window

Deleting images from your local database while you are attempting to send files to a destination may cause the transmission to fail; therefore, complete your send action before deleting images.

Note: Before you delete an image from your local database you should first archive it to a local or DICOM archive. For more information about archiving, see *Archiving Images* on page 65.

To delete an image, do one of the following:

- On the *Preview* window, select a thumbnail image. To make multiple selections, hold the CTRL key while clicking. The image or images are marked with an x. Drag the image(s) from the *Preview* window and drop them in the Recycle Bin. Confirm or cancel your delete action at the prompt.
- On the *Preview* window, right-click a thumbnail image. To make multiple selections, hold the CTRL key while left clicking, then right-click any selection. The right-click menu appears. Scroll to *Delete,* then click. Confirm or cancel your delete action at the prompt.
- On the *Preview* window, right-click a thumbnail image. To make multiple selections, hold the CTRL key while left clicking. Press the keyboard Delete key.

Font Size

You can alternate between normal and large font size in the ***Patients*** and ***Communications*** window by toggling the font size button.

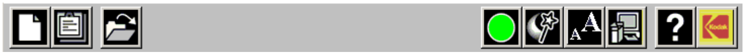
- From the ***Patients*** window toolbar, click **Font Size**.

Patients

From the ***Patients*** window, you can:

- Create or edit Patient and Study Information
- Use the drag-and-drop feature to move Images, Studies, or Series into another Patient, Study, Series
- Manage the Patients list through sorting, archiving, and deleting patient records
- Select images from Patients, Studies, and Series to view, send, print, manipulate, window/level, and process
- Perform quality assurance self-test functions — only on an attached ACR-2000 scanner
- Drag-and-drop Patients, Studies, Series, and Images to destinations on the *Communications* window for transmission to another location, archiving to a local or remote DICOM archive, DICOM printing, or to delete via the Recycle Bin
- Access the Scan Wizard (CR only)
- Access the application Setup window
- Access online help
- View information about KODAK General Radiography Software and the workstation disk space and memory

Patients Toolbar



Select a button from the Patients toolbar to activate the following functions.

New Patient

Click **New Patient** to open the ***Patient and Study Information*** window, where you enter associated medical information about a new patient. For more information, see *Patient and Study Information* on page 27.

Patient/Study Information

Click **Patient/Study Information** to open the ***Patient and Study Information*** window, where you view associated medical information for the selected Patient or Study. If there are no Patients or Studies on the window or if a Patient or Study is not selected, **Patient/Study Information** appears dimmed. For more information, see *Patient and Study Information* on page 27.

Display Images

Click **Display Images** to open the ***Image Display*** window and display patient images you have selected. For more information, see *Image Display Window and Toolbars* on page 37.

Self-Test

CR Only

Click **Self-Test** to perform an ACR-2000 scanner self-test and open the ***Self-Test*** window, which displays the overall status of the ACR-2000 scanner. The self-test button reflects the status of the last self-test performed. For more information, see Performing the ACR-2000 Self-Test.

Note: This button will only appear on the toolbar if an ACR-2000 scanner is attached to the KODAK General Radiography Software workstation.

Scan Wizard

CR Only

Click **Scan Wizard** to save time and enable KODAK General Radiography Software to prompt you to enter an accession number and other patient information necessary for scanning images into automatically displayed windows. For more information, see Scan Wizard.

Font Size

Click **Font Size** to enlarge the information in the ***Patients*** window. Click **Font Size** again to toggle back to the smaller font. For more information, see Font Size.

Setup

Click **Setup** to open the ***Setup*** window, which allows you to view settings and administrators to configure Window Level, Scanner, Modality, Image Processing, DICOM Communication, and Application Settings. For more information, see the *KODAK General Radiography Software Administrator's Reference Guide.*

Help

Click **Help** to display online help.

About

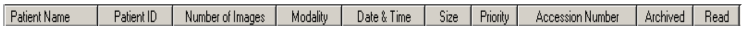
Click **About** to display information about KODAK General Radiography Software and the workstation disk space and memory.

Patients List

The Patients list displays patient information in the DICOM hierarchy format: Patient, Study, Series, Image. Each level shows the information appropriate to that level.

You can display or hide a level by clicking the **+** or – above that level. Some of the levels of the Patients list can be expanded by clicking the **+** at the DICOM database level.

Patients List Column Headings



The Patients list displays information retrieved from the ***Patient and Study Information*** window.

- **Patient Name —** Name of the patient.
- **Patient ID** —Identification number assigned to the patient.
- **Number of Images** — Total number of images in the Patient, Study, or Series levels.
- **Modality** — The specific modality associated with the image.
- **Date & Time** — Date and time the study, series or image was created.
- **Size** — Size, in kilobytes or megabytes (KB or MB), of the Patient, Study, Series, and Image files or levels. The total size at the Patient level may not equal the sum of the Study,

Series, and Image levels due to rounding.

- **Priority** — Stat, Regular, Low. The Patient level displays the priority of the highest priority series.
- **Accession Number** — Patient visit identification. This displays at the Study level.
- **Archived** — The archive status of patient images.
    - **N** — Image is not archived.
    - **Y** — Image or study is archived on either the local archive or a DICOM archive.

Note: Images received from remote locations are considered archived by KODAK General Radiography Software and are marked Y.

- **Read** — Indicates whether image has been marked as Read or Unread.
    - **N** — Image is unread.
    - **Y** — Image is read.

Patients List: Viewing and Sorting

Viewing all columns/patients:

- Use the scroll bars located on the right side and at the bottom of the window.

Resizing a column:

- Click on a dividing line to the right of a column heading and drag it to resize the column.

Sorting by column heading:

- Click any column heading to sort the list by the selected column heading and to alternate between ascending and descending sort order.

Selecting, Viewing, and Manipulating the Patients List

Patients Window Resizing

The ***Patients*** window displays the Patients list, which presents patient information in the DICOM hierarchy format. You can expand some levels in the list by clicking the **+** or – above that level. The entire patients list can be expanded by clicking the DICOM database level.

You can resize the ***Patients*** window by clicking on the dividing line at the top of the window and dragging up or down or on the dividing line to the left of the window and dragging right or left. You can use the scroll bars at the right side and at the bottom of the screen to view patient information when there is more information presented than can fit on the window.

Item Selection

From the Patients list you can select one or more Patients, Studies, Series, or Images. To select multiple items, **CTRL left-click** multiple items.

Right-Click Menu

The Patients right-click menu provides access to some of the Patients toolbar functions. For descriptions of the toolbar functions, see *Patients Toolbar* on page 22.

Searching for a Patient or Study for Image Setup

CR Only

To search for a Patient or Study for Image Setup, do the following:

1. Select the Database line on the Patients Window.
2. Click **Scan** . The ***Image Setup*** window is displayed with the **Patient ID** and **Accession Number** blank.
3. Enter either a **Patient ID**, if you are searching for a Patient, or **Accession Number**, if you are searching for a Study.
4. Select a **Body Part**, **Projection**, and **Grid Removal** option.
5. Click **Scan**.

Patient and Study Information

The ***Patient and Study Information*** window displays clinical information associated to each image in a Patient/Study/Series.

- Click **New Patient** from the Patients Window.

Patient and Study Information Fields

You must type a value in all fields marked by an asterisk. The Patient and Study Information fields are:

Patient Data

- ***Patient Last Name** — Last name of the patient.
- **Patient First Name** — First Name of the patient.
- ***Patient ID** — Identification number assigned to the patient, which you type using up to 64 case-sensitive alphanumeric characters, excluding the apostrophe ('), the backslash (\), and the pipe (|).
- **Social Security Number** — SSN of the patient, which you type using alphanumeric characters.
- **Date of Birth** — DOB of the patient, which you can select from the drop-down box. You must enter a date equal or previous to the current date.
- **Sex** — Gender of the patient, which you select from a drop-down list displaying M (male), F (female), and O (other), where O is the default value.

Study Data

- **Accession Number** — Patient visit ID, which you type using alphanumeric characters.
- **Study Description** — Notes on the description of the study performed, which you type using alphanumeric characters.
- **Institution** — Location where the study was conducted, which you type using alphanumeric characters.
- **Operator** — Name of the technologist who captured the study, which you type using up to 64 alphanumeric

characters.

- ***Study ID*** — Study identification number, that is generated by the program using alphanumeric characters (excluding the apostrophe) and which you can modify.
- **Priority Code** — Priority code of the patient, which you select from a drop-down list displaying Low, Regular, and Stat, where Regular is the default value.
- **Institution Phone** — Phone number of the location where the study was conducted, which you type using up to 16 alphanumeric characters.
- **Study Date** — System generated date that the study was created. Select a date from the drop-down box.
- **Study Time** — System generated time that the study was created, which can be modified by you and typed in the 24-hour time format ***hh:mm:ss***.

Series Data

- ***Modality** (Digitizer only) — Type of radiography performed, which you select from a drop-down list displaying the values that were set up during KODAK General Radiography Software installation.

Physician Data

- **Referring Physician** — Name of the referring physician, which you type using up to 64 alphanumeric characters.
- **Referring Physician Phone** — Phone number of the referring physician, which you type using alphanumeric characters.
- **Requesting Physician** — Name of the physician who requested the study, which you type using up to 64 alphanumeric characters.
- **Requesting Physician Phone** — Phone number of the requesting physician, which you type using alphanumeric characters.

Exam Information

- **Exam Information** — Information you type using alphanumeric characters and punctuation. Use the scroll bar on the right side of the window when there is more information than can be displayed by the text box.

Patient and Study Information Functions

New Patient

Click **New Patient** to create a new patient, automatically save the current record, and clear text boxes for new input.

New Study

Click **New Study** to create a new study, automatically save the current record, and clear text boxes for new input.

Save

Click **Save** to save the current values entered in the ***Patient and Study Information*** window and return to the ***Application Main Window.***

Cancel

Click **Cancel** to return to the ***Application Main Window*** without saving changes.

Selecting a Patient for Image Setup

To select a Patient for the **Image Setup** window, do the following:

1. Select a **Patient Name** from the **Patients** window.
2. Click **Scan**. The **Image Setup** window is displayed with the **Patient ID** in the Patient Box.
3. Select a **Body Part**, **Projection**, and **Grid Removal** option.
4. Click **Scan**.

Selecting a Study for Image Setup

To select a Study for the **Image Setup** window, do the following:

1. Select a **Patient Study** from the **Patients** window.
2. Click on **Scan**. The **Image Setup** window is displayed with the **Patient ID** and **Accession Number** in the Patient Box.
3. Select a **Body Part**, **Projection**, and **Grid Removal** option.

4. Click **Scan**.

Creating a New Patient

1. Click **New Patient** on the Patients toolbar. The ***Patient and Study Information*** window opens.
2. Type the new patient information. Fields requiring input are marked with an asterisk. For a list of required fields and descriptions of all Patient and Study Information fields, see Patient and Study Information Window.
3. Do one of the following:
   - Click **New Patient** to save the current entry and create a new patient.

   – or –

   - Click **New Study** to save the current entry and create a new study.

   – or –

   - Click **Save** to save the entry, close the window, and return to the ***Patients*** window.

   – or –

   - Click **Cance**l to close the window without saving any entries and return to the ***Patients*** window.

Editing a Patient Record

Note: Images received from a remote location, or that have been archived, cannot have their Patient Name or Patient ID information edited.

To edit a patient’s demographic information:

1. Select a **Patient** on the Patient List. Click **Patient**/ **Study**

Information on the Patients toolbar. The ***Patient and Study Information*** window opens.

2. Edit the patient information. Only fields in the **Patient Data** and **Exam Information** portion of the form will be editable. For a description of all Patient and Study Information fields, see Patient and Study Information Window.
3. Click **Save** to save the edited entry or click **Cance**l to close the window without saving any entries.

Creating a New Study

1. Click **Patient and Study Information** . The ***Patient and Study Information*** window opens.
2. Click **New Study**.
3. Type the new study information. Fields requiring input are marked with an asterisk. For a list of required fields and descriptions of all Patient and Study Information fields, see Patient and Study Information Window.
4. Do one of the following:
   - Click **New Study** to save the current entry and create a new study.

   – or –

   - Click **New Patient** to save the current entry and create a new patient.

   – or –

   - Click **Save** to save the entry, close the window, and return to the ***Patients*** window.

   – or –

   - Click **Cancel** to close the window without saving any entries and return to the ***Patients*** window.

Editing a Study Record

Note: Images received from a remote location, or that have been archived, cannot have their Patient Name or Patient ID edited.

To edit a study's demographic information:

1. Select a study on the Patient List. Then click **Patient/Study Information** on the Patients toolbar. The ***Patient and Study Information*** window opens.
2. Edit the study information. Only fields in the **Study Data** and **Physician Data** portion of the form will be editable. For a description of all Patient and Study Information fields, see Patient and Study Information Window.
3. Click **Save** to save the edited entry, or click **Cance**l to close the window without saving any entries and return to the ***Patients*** window.

Moving an Image to another Patient, Study or Series

1. From the ***Patients*** window, select the desired image from the Patient, Study, Series or Unassigned Images (digitizer only) category.
2. Drag the image and drop it into an existing Patient, Study or Series category.
3. Confirm your action by clicking **Save** or to stop the action, click **Cancel**.
4. If the desired Patient, Study or Series is not listed in the ***Patients*** window, Create a New Patient first, then use the drag-and-drop feature to move the image to the desired location.

WARNING: If you have moved an image, ensure that it is in the correct location listed in the Patients window; otherwise the image could be assigned to the wrong patient, study, or series.

Unassigned Images

Digitizer Only

An unassigned images category is automatically created in the ***Patients*** window when images are scanned with a film digitizer without first selecting a patient, study, or series. With the Database line or existing Unassigned images category selected, the scanned images will be displayed in the respective category. If the Database line is selected and an Unassigned category does not exist, an Unassigned category is created. This process is useful when scanning multiple films.

Archiving Patient Records

Note: If you are performing scans with an ACR-2000, you should always archive all images acquired at your workstation.

You can archive patient records to either or both a local archive and a DICOM archive .

View and Manipulate Images

Selecting Images

You can select images from the Main Application window in the following ways:

- **Left Click —** Provides the standard method of selecting a thumbnail image. You can then apply a function from the toolbar.
- **Control Left-Click** — Allows you to select multiple non-contiguous items. You can then apply a function from the toolbar or right-click menu to the active images.
- **Right Click —** Selects a thumbnail image and opens the right-click menu, which duplicates some of the toolbar functions for the active image.

Displaying Images

Individual images

Do one of the following to select images to display from the Patient list:

- Double-click the patient/study/series/image.
- Select the patient/study/series/image and click **Display Image** on the ***Patients*** window toolbar.

- Select the patient/study/series/image. Right-click and select **Display Image** from the right-click menu.

Multiple Images

Do one of the following to select multiple images to display from the Patient list:

- To select multiple continuous patients/studies/series/images to display, select a continuous block of lines, click the first line, press and hold **SHIFT**, and then click the last line. Then click **Display Image** .
- To select multiple non-adjacent patients/studies/series/images, from the Patient list, press and hold **CTRL** while you click each line. Then click **Display Image** .

Applying Functions to Images

Apply Functions to an Active Image

From the Image Display window:

1. Open an image.
2. Click a button on the toolbar. Repeat to apply more functions to the image.
3. Click **Save** to save the image manipulations or click **Undo** to revert to the last-saved version of the image.

Apply a Function to a Single Thumbnail

From the Preview window:

1. **Right-click** a single thumbnail image. The right-click menu appears.
2. Scroll to the function you want to apply, then click. The right-click menu disappears.

3. Click **Save** to save the image manipulations or click **Undo** ↶.

Apply a Function to Multiple Thumbnail Images

From the Preview window:

1. **CTRL** left-click multiple thumbnail images. The images are marked with an ***X***.
2. **CTRL** right-click any selection. The right-click menu appears.
3. Scroll to the function you want to apply, then click. The right-click menu disappears.
4. Click **Save** to save the image manipulations or click **Undo** ↶.

Apply a Function to Multiple Items in the Patient List

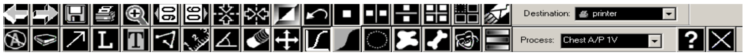
From the Patients window:

1. **CTRL left-click** multiple items.
2. **CTRL right-click** any selection. The right-click menu appears.
3. Scroll to the function you want to apply, then click. The right-click menu disappears.

Image Display Window and Toolbars

In the Image Display window, you can view, manipulate, process, window/level, annotate, send and print patient images.

Image Display Toolbars



Destination: printer

Process: Chest A/P 1V

When you click a button, the button's function is applied to the active image.

Active Images

An image becomes active when you click it; then use toolbar functions to manipulate the image.

Previous

Click **Previous** to display the previous image in a multiple selection. **Previous** is available only when a previous image exists.

Next

Click **Next** to display the next image in a multiple selection. **Next** is available only when the next image exists.

Save

Click this button to save any image manipulations you applied to an active image.

Windows Print

Click this button to send a selected image to a Windows printer. For more information, see *Printing to a Windows Printer* on page 62.

Magnification

Use Magnification to:

- Set a magnification factor at which to zoom.
- Zoom in on an image.
- Zoom out on an image.
- Magnify a portion of an image.
- Pan across an image.

Magnification changes do not forward when you send an image to other DICOM nodes.

Set a Magnification Factor at Which to Zoom

1. Position the cursor over the **Magnifier** button.
2. Double-click **Magnifier** to activate the magnification factor, which appears in the status bar at the bottom of the screen.
3. Continue to double-click **Magnifier** to advance to the magnification factor at which you want to zoom.

Zoom In on an Image

1. Click **Magnification** to activate the magnifier cursor.
2. Double click an image. Each double-click of the image zooms in according to the magnification factor currently in effect, which appears in the status bar at the bottom of the screen.

Zoom Out on an Image

1. Click **Magnification** to activate the magnifier cursor.
2. Double right-click an image. Each double right-click of the image zooms out according to the magnification factor currently in effect, which appears in the status bar at the bottom of the screen.

Magnifying a Portion of an Image

1. Click **Magnification** to activate the magnifier cursor.
2. Click an image and hold. The magnification box appears. The portion of the image appearing within the bounds of the magnification box appears enlarged.
3. Continue holding the mouse button and moving the magnification box across the image to magnify other areas of

the image.

Pan an Image

1. With **Magnification** pressed, right-click the image and hold the mouse button. The cursor changes to the pan cursor.
2. Drag across the image and release the mouse button to stop.

Flip and Rotate Functions

The toolbar has two flip and two rotate functions that you use to ensure proper orientation of the image prior to saving or sending:

Flip Vertical

Click this button to flip an active image vertically.

Flip Horizontal

Click this button to flip an active image horizontally.

Rotate Left

Click this button to rotate an active image 90^{o} left.

Rotate Right

Click this button to rotate an active image 90^{o} right.

Black/White

Click this button to toggle an image between normal gray scale (negative image) and reverse gray scale (positive image).

Undo

Click this button to revert all image manipulations you applied to an active image to the last save you performed on the image.

Displays

One-on-One Display

Click this button to display one image at a time on the screen.

Two-on-One Horizontal Display

Click this button to display two side by side images on the screen.

Two-on-One Vertical Display

Click this button to display two images top and bottom on the screen.

Four-on-One Display

Click this button to display four images at a time on the screen.

Synchronize Images

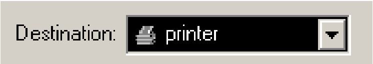
Click this button to synchronize manipulations to all displayed images.

WARNING: If you manipulate or process images while synchronization is on, images could be affected that are currently not being viewed on the screen.

SpeedSend

Click this button to send an active image to a location selected in the Destination drop-down list.

Destination



Destination: printer

Select a location to which you want to send an active image from the Destination drop-down list.

Hide Text Overlay

Click this button to toggle display of the DICOM text overlays and annotations on an image.

Read/Unread

Click this button to mark the image as read or unread.

Note: The Read/Unread flag is only local and all sent or retrieved images will appear as Unread.

WARNING: The Read/Unread feature is intended to be used only by the diagnosing physician. Use care when marking images with the Read/Unread flag.

Reference pointer

Click this button to launch the cursor , then mark or pinpoint an area of interest on the image. An arrow will appear on the image where you clicked it. You can annotate an image with reference pointers angled at 45, 135, 225 or 315 degrees.

Changing the Angle of a Reference Pointer

1. Right-click a reference pointer.
2. From the right-click menu select Change Pointer to 45, 135, 225 or 315 degrees. The arrow changes respectively.

L-Placing

Click this button to launch the cursor , then click a place on the image that you want to denote as the left side. With this notation in place, you won't lose the orientation of the image as it is rotated and flipped.

Free Text

Click this button to launch the cursor , then click a place on the image where you wish to place an annotation. A text box is created on the image where you can freely type notes.

Draw Lines

Click this button to launch the cursor , then click a place on the image where you wish your lines to start. Multiple clicks result in multiple lines as you move the mouse. Right-click to discontinue drawing the lines.

Distance Measurement

Click this button to launch the cursor , and measure the distance between two points on an image. Click a place on the image where you want your measurement to start. Click again where you want your measurement to end.

Angle Measurement

Click this button to launch the cursor , and measure the angle between a vertex and two endpoints on an image.

Erase annotation

Click this button to launch the cursor , and enable you to erase annotations on an item-by-item basis.

Move annotation

Click this button to launch the cursor , and move annotations from place to place on the image.

Automatic Window/Level

Click this button to automatically apply a window/level value calculated for the active image.

Clicking **Automatic Window/Level** will automatically:

- Apply a window value that is calculated from the difference between the highest pixel value and the lowest pixel value.

- Apply a level value that is calculated as the midpoint between the highest and lowest pixel value.

Dynamic Window/Level

Click this button to launch the cursor . The window/level cursor enables you to dynamically control window width and center on an image.

1. Click **Dynamic Window/Level** to activate the window/level cursor.
2. Click the image on the point you wish to window/level, and hold. This specifies the anchor point of the subwindow.
3. As you drag the cursor, the subwindow appears. As you continue to drag, the subwindow displays changes.

To change the center of the window (change brightness):

- Move the cursor down to increase brightness or up to decrease brightness.

To change the width of the window (change contrast):

1. Move the cursor left to increase contrast or right to decrease contrast.
2. Release the cursor when you are satisfied with the changes. The subwindow closes and the window/level changes reflect on the full-size image.

Air W/L

Click this button to apply a set window/level value optimized for an image whose focus is air.

Tissue W/L

Click this button to apply a set window/level value optimized for an image whose focus is tissue.

Bone W/L

Click this button to apply a set window/level value optimized for an image where focus is bone.

Default Window/Level Settings for Preset Buttons

- Preset **Air** : width 1600, center 424
- Preset **Tissue** : width 350, center 1074
- Preset **Bone** : width 2000, center 1524

Window/level values are saved and forwarded when you send an image to other DICOM nodes.

Window/Level Settings on DICOM Text Overlay

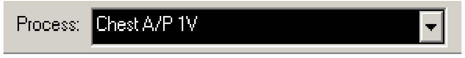
On the DICOM text overlay, **W** (width/window) and **C** (center/level) settings display in the lower-left corner of the image.

Apply Mask

Click this button to mask collimated areas of the selected image.

Set Image Processing

Click this button to display the image processing dialog box. The image processing dialog box allows you to configure image processing on the basis of examined body part and patient position. You can also choose to save a process for use as a preset in the process list box.



Process: Chest A/P 1V

Process

From the **Process** drop-down list, select a preset image process that you want to apply to an active image.

Note: Image processing is optimized for CR plates digitized by an attached ACR-2000 scanner.

For more information, see *Processing Images* on page 49.

Help

Click this button to access this on-line help system.

Exit

Click this button to close the ***Image Display*** window and return to the main application window.

Processing Images

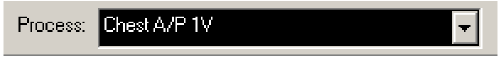
Image processing provides a method for enhancing image quality by increasing contrast and eliminating some image artifacts. Although some image processes, such as Grid Removal, may be beneficial when applied to digitized radiology film, image processing is optimized for CR plates scanned by an attached ACR-2000.

WARNING: Image processing applied to some images may result in an image that is not adequate for diagnostic viewing.

WARNING: Processing images not acquired with an ACR-2000 may result in non-diagnostic quality images.

Applying a Preset Image Process

1. From the image display window, select a process value from the Process drop-down list. The image reflects the image process.



Process: Chest A/P 1V

- **Unprocessed** — Removes processing from the image
- **VGRIDREM** — Vertical Grid Removal, removes vertical grids from an image
- **HGRIDREM** — Horizontal Grid Removal, removes horizontal grids from an image

- User Presets **1** through **9** — Administrator configurable image processes.

Note: An image can hold only one image process value. When you select another image process, KODAK General Radiography Software returns the image to its unprocessed version first, then applies the selection.

2. Then do one of the following:
   - Select another process from the Process drop-down list.

     – or –
   - To remove processing from the image, from the Process drop-down list, select Unprocessed.

     – or –
   - To save the image process, click **Save** .

     – or –
   - To return the image to its last saved setting, click **Undo**.

Image processing information is stored in the DICOM header and only the unprocessed version of the image is archived.

Setting an Image Process for an Image

1. Click Set Image Processing from the ***Image Display*** window toolbar.
2. Select a body part that corresponds to the active image subject from the **Body Part** drop-down list. If you are performing quality assurance testing with a test pattern image, select **Test Pattern**.
3. Select a **Position** option that corresponds to the patient position.
   - **A/P** — Anterior/Posterior
   - **P/A** — Posterior/Anterior

   - **LAT** — Lateral
   - **OBL —** Oblique
   - **DEC —** Decubitus
4. Select a Grid Removal option of **None**, **Horizontal** or **Vertical**.
5. If you want to continue to try various processing options on the active image, click **Apply**. This will apply the currently configured process to the active image and leave the dialog box open for further processing.
6. Click **OK**.

Unprocessing an Image and Removing Annotations

There are times you will want to send an image in its raw format after it has already been processed. You can either have the receiver of the image Query/Retrieve the image, in which case they receive the raw format, or you can do the following to unprocess the image and remove annotations.

To unprocess an image:

1. Open the image(s) in the **Image Display** window.
2. Click synchronize if more than one image is displayed, then select **Unprocessed** from the Process drop-down list. The image reflects the image process.
3. Remove any annotations by doing the following:
   - Click **Erase Measurement** . The arrow cursor changes to an eraser tip cursor. Position the eraser tip on the annotation you want to erase and click.
4. Click **Save** .The image is saved without annotations and returned to its unprocessed version.

Image Setup Window

If an ACR-2000 is attached to the application workstation, the **Image Setup Window** will be displayed each time **Scan** is invoked. The **Image Setup Window** provides pre-processing and requires that you:

1. Enter or Accept a Patient ID or Accession Number to which the image will be associated.
2. Select a **Body Part** for the image.
3. Select a **Projection** option that corresponds to the patient position on the active image.
    - **A/P** — Anterior/Posterior
    - **P/A** — Posterior/Anterior
    - **LAT** — Lateral
    - **OBL —** Oblique
    - **DEC —** Decubitus
4. Choose if you want to have vertical or horizontal grid removal on or off by clicking the **No**, **Horizontal**, or **Vertical** option.

Note: If you elect not to apply Grid Removal as part of the image's pre-processing, you can apply it later as part of the Image Display Window's Image Processing Dialog Box or the Process drop-down list on the Image Display Toolbar.

Annotating Images

WARNING: Annotations/measurements are for reference only and are not intended for diagnostic use.

You can annotate your images with the following annotation buttons from the ***Image Display*** window toolbar, then save and send the image. All annotations scale and rotate with the image. All annotation information can be saved along with the image and sent to other destinations.

- Reference Pointer
- L-Placing
- Free Text
- Draw Lines
- Measure Distance

- ∡ Measure Angle

Annotation Color

You can alternate between black and white annotations using the right-click menu.

1. From the Image Display window, ensure you are in the annotation mode by selecting an annotation from the toolbar.
2. Right-click an image.
3. From the right-click menu, select **Invert Annotation Color**. All annotations on the image change to black or white.

Annotation Size

You can change the annotation size created using the Reference Pointer ↗, Free Text T, and L-Placing L by using the right-click menu.

1. From the Image Display window, ensure you are in the annotation mode by selecting an annotation from the toolbar.
2. Right-click the annotation on an image.
3. From the right-click menu select **Increase Annotation Size** to enlarge the size of the annotation or select **Decrease Annotation Size** to make the annotation smaller.
4. Repeat to continue increasing or decreasing the size of the annotation.

Moving Annotations

1. Click **Move Annotation** . The arrow cursor changes to a moving tip cursor .
2. Position the cursor on the annotation you want to move, press the button and hold it while you move the annotation to the desired location.
3. Click **Move Annotation** to release the button and reactivate the Image Display window toolbar.

Erasing Annotations

1. Click **Erase Annotations** . The arrow cursor changes to an eraser tip cursor.
2. Position the eraser tip on the annotation you want to erase and click. Continue clicking each annotation you want to erase.
3. Click **Erase Annotations** to release the button and reactivate the Image Display window toolbar.

Deleting Annotations

You can delete annotations using the right-click function.

1. From the Image Display window, ensure you are in the annotation mode by selecting an annotation from the toolbar.
2. Right-click an annotation on an image. The right-click menu is displayed.

3. Select **Delete Annotation**. The annotation is deleted.
4. Repeat the function for each annotation.

Measurements

You can apply angle and distance measurements to one image at a time.

WARNING: Measurements are for reference only and not intended for diagnostic use.

Measuring Distance

You can measure distance in centimeters, accurate to the nearest 1/10 cm.

1. Click **Distance Measurement** . The arrow cursor changes to a Distance Measurement cursor.
2. Position the plus cursor where you want to anchor the first endpoint and click.
3. Move the plus cursor where you want to place the second endpoint and click. A line connects the two points and the distance annotation appears at the center of the line.
4. Perform another measurement or click **Distance Measurement** to release the button and reactivate the

Image Display Window toolbar.

Measuring Angles

You can measure angles in degrees, accurate to the nearest 5 ^{o}.

1. Click **Angle Measurement** ∠. The arrow cursor changes to an angle cursor.
2. Position the cursor where you want a line to begin and click.
3. Move the angle cursor where you want the line to end and click. A line connects the two points.
4. Move the pointer where you want to place the second line and click.
5. Move the angle cursor where you want to place the second line's endpoint and click. A line connects the two points and the angle measurement is displayed.
6. Perform another measurement or click **Angle Measurement** ∠ to release the button and reactivate the ***Image Display*** window toolbar.

Sending Images

SpeedSend

Click **SpeedSend** to send a saved, active image to the location selected in the **Destination** drop-down list.

1. Display an image in the Image Display window. For more information, see Displaying Images.
2. Select a location to send the image from the **Destination** drop-down list.
3. Click **SpeedSend** .

Sending Patients, Studies, Series and Images

You can send one or more items to a destination called a node. For more information about sending to a destination and/or about creating Address entries, see the *System Administrator's Reference Guide.*

WARNING: When an image with processing or annotations is sent, the image pixel data is modified to include any processing and annotations. Once the image is received at the remote station, the processing and annotations cannot be removed from the image.

Note: If the user at the remote viewing station would like to see the unprocessed or unannotated image, the user at the source station must remove processing or annotations, save the image, and send it to the remote station.

1. On the ***Communications*** window, select a destination nickname from the Nodes column.
2. On the ***Patients*** window, select the Patient, Study, Series, or Image that you want to send. To make multiple selections, hold the **CTRL** key while clicking. Then do one of the following:
   - Click **Send** .

     – or –
   - Right-click. The right-click menu appears. Scroll to ***Send*** and click.

     – or –
   - Drag the items from the Patients window and drop them in the Node in the ***Communications*** window.

Files are sent to the selected destination. The status bar displays the sending status.

Printing Images

Printing to a DICOM Printer

You can print multiple images, including the images annotations and any window/level information or processing information, to a DICOM printer. You can simply use the drag-and-drop feature to move the images to the node specified for DICOM printing in your Communications window or follow the directions below.

Note: When you send an image that has been processed to a DICOM printer, the processed image, not the raw image, prints.

WARNING: The DICOM printing capability is intended for reference only and not for diagnosis.

Sending an image to a DICOM printer from the *Main Application* window:

1. On the ***Communications*** window, select a **DICOM printer** node.
2. On the ***Patients*** window, select the image(s) you want to print. To make multiple selections, hold the **CTRL** key while clicking. Then do one of the following:
   - **Click** Send .

     – or –
   - Right-click. The right-click menu appears. Scroll to ***Send*** and click.

     – or –
   - Drag the image(s) from the **Patients** window and drop

images in the **DICOM printer node**.

The **DICOM Print: Printer** dialog opens.

3. From the **DICOM Print: Printer** dialog, select the Page Layout: 1x1, 1x2, 2x2, 3x3, or 4x4. The Number of Pages field adjusts accordingly.
4. Select the appropriate tray associated with the film orientation: Portrait or Landscape.
5. Click **OK**. Ensure the images printed to the selected tray.

Sending an image to a DICOM printer from the Image Display window:

1. Open the images in the **Image Display** window.
2. Select a DICOM printer node in the **Destination** drop-down list.
3. Click SpeedSend .
4. Follow steps 3-5 above.

Printing to a Windows Printer

From the ***Image Display*** window, you can print multiple images on a single sheet, including the DICOM overlay, to a Windows printer. Windows print capabilities support gray scale printing only.

Note: When you send an image that has been processed to a Windows printer, the processed image, not the raw image, prints.

WARNING: The Windows printing capability is intended for reference only and not for diagnosis.

Sending Images to a Windows Printer

1. On the ***Patients*** window, select the image(s) you want to print. To make multiple selections, hold the **CTRL** key while

clicking.

2. Open the image(s) by doing one of the following:
   - Right-click and selecting **Display Image**
   - Double-click the selection(s)
   - Click **Display Image** .
3. If you selected multiple images to print, click Synchronize .
4. Click **Windows Print** **.** The ***Windows Print*** dialog box opens.
5. Select the Page Layout: 1x1, 1x2, 2x2, 3x3, or 4x4.
6. Select the number of copies to be printed.
7. The page orientation for the printing defaults to the setting of your Windows printer.
8. Click **OK**. The image(s) print including the DICOM overlay.

Archiving Images

Note: If you are performing scans with an ACR-2000, you should always archive all images acquired at your workstation.

You can archive patient records to either or both a local archive and a DICOM archive .

Archiving Images to a Local Archive

When you perform a Local archive, KODAK General Radiography Software sends the selected images to one of the nodes specified by your system administrator.

When you archive images to a local archive, you can use the drag-and-drop feature to move the images to the node specified for your local archive in your Communications window.

Note: When you archive images, image processing and window/level information are stored in the DICOM header.

1. In the ***Communications*** window, select a Local archive nickname.
2. In the ***Patients*** window, select the Patients or Studies you want to send to the Local archive. To make multiple selections, hold the **CTRL** key while clicking. Then do one of the following:
    - Click **Send** .

      – or –
    - Right-click in either the ***Patients*** or ***Communications***

window. The right-click menu appears. Scroll to ***Send*** and click.

– or –

- Drag the selection(s) from the Patient's window and drop them into the local archive of the ***Communications*** window.

KODAK General Radiography Software verifies that records sent are successfully received by the Local archive.

- If the Local archive is successful, the **Archive** column reflects a ***Y*** archive status for the image.
- If the Local archive is unsuccessful, the **Archive** column reflects an ***N*** archive status for the image.

Archiving Images to a DICOM Archive

When you archive images to a DICOM archive, you can use the drag-and-drop feature to move the images to the node specified for your DICOM archive in your Communications window.

Note: When you archive images, image processing, annotations and window/level information are stored in the DICOM header. The unprocessed version of the image is archived.

1. On the ***Communications*** window, select a DICOM archive nickname.
2. On the ***Patients*** window, select the Patients or Studies you want to send to the DICOM archive. To make multiple selections, hold the **CTRL** key while clicking. Then do one of the following:

- Click **Send** .

– or –

- Right-click. The right-click menu appears. Scroll to ***Send*** and click.

– or –

- Drag by holding the left mouse button and moving the cursor to the ***Communications*** window. The cursor changes when you can drop images onto the selected DICOM archive. Release the mouse button.

KODAK General Radiography Software verifies that records sent are successfully received by the DICOM archive. Verification begins 30 seconds after the records have been sent.

- If the DICOM archive is successful, the **Archive** column reflects a ***Y*** archive status for the image.
- If the archive is unsuccessful, the **Archive** column reflects an ***N*** archive status for the image, and the failure is recorded in a log file. For more information, see Open a Log File.

Deleting Images

Deleting images from your local database while you are attempting to send those images to a destination may cause the transmission to fail; therefore, be sure your transmission of those images has completed before deleting the images.

Note: Before you delete a CR image from your local database, you should first archive it to a local or DICOM archive. For more information about archiving, see *Archiving Images* on page 65.

To delete images, do one of the following:

- On the ***Patients*** window, select the Patient, Study, Series, or Image. To make multiple selections, hold the **CTRL** key while clicking. Drag the selections and drop them into Recycle Bin.

– or –

- On the ***Patients*** window, right-click the **Patient**, **Study**, **Series**, or **Image**. To make multiple selections, hold the **CTRL** key while left clicking, then right-click any selection. The right-click menu appears. Scroll to ***Delete***, then click.

Recycle Bin

CR Only

The **Recycle Bin** — the trash can icon located on the lower-left corner of the Communications window — permits you to delete and restore unarchived images.

All images on a system with a film scanner, when deleted, are permanently deleted.

- Position your cursor over the Recycle Bin to display the ToolTip. The ToolTip displays the contents of the Recycle Bin and available space.

WARNING: Archived images placed in the Recycle Bin are permanently deleted and cannot be restored via the Recycle Bin.

When unarchived Patient images are in the **Recycle Bin**, the trash can will inflate. Double-clicking the trash can icon displays the ***Recycle Bin window***, where unarchived images can be restored to the application main window.

Note: Only administrators can permanently delete unarchived images.

Recycle Bin Window

Double clicking the trash can icon displays the ***Recycle Bin window***, where unarchived images can be restored to the application main window.

The ***Recycle Bin window*** displays patient information in the DICOM hierarchy format: Patient, Study, Series, Image. Each level shows the information appropriate to that level.

You can display or hide a level by clicking the **+** or – above that level. You can expand some levels in the list by clicking the DICOM database level.

The ***Recycle Bin window*** displays information in the following sortable columns:

- Patient Name — Name of the patient.
- Patient ID — Identification number assigned to the patient.
- Number of Images — Total number of images in the Patient, Study, and Series levels.
- Date & Time — Date and time the study was created.
- Size — Size, in kilobytes or megabytes (KB or MB), of the Patient, Study, Series, and Image files or levels. The total size at the Patient level may not equal the sum of the Study, Series, and Image levels due to rounding.
- Priority — Stat, Regular, Low. The Patient level displays the priority of the highest priority series.
- Accession Number — Patient visit identification.

Restoring Images From the Recycle Bin

1. Select a **Patient**, **Study**, **Series**, or **Image** from the displayed list that you want to restore. Click on an item to select it, or to make multiple selections, hold the control key while clicking each item.
2. Click **Restore** . The selected items will be restored to the *Patients window*.

Note: *This option will only be available when an item has been selected to restore.*

Permanently Deleting Images From the Recycle Bin

Note: *This option is only available to administrators.*

1. Select the unarchived **Patients**, **Studies**, **Series**, or **Images** from the displayed list that you want to permanently delete. Click on an item to select it, or to make multiple selections, hold the control key

while clicking each item.

2. Click **Delete** .

Note: *CR Images should* **always** *be archived before being permanently deleted.*

Closing the Recycle Bin

- Click **Exit** to close the ***Recycle Bin*** window.

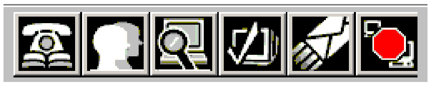
Communications

Communications Window

From the ***Communications*** window you can:

- Create and edit remote-site, local archive, DICOM archive, worklist broker, DICOM printer, and group address entries. (Administrator function.)
- Send files to **individual** and **group sites**.
- View lossy file-compression status of address nicknames on the *Nodes* column.
- Perform and accept **DICOM query** operations to and from other DICOM nodes.
- Perform and allow **DICOM retrieve** operations to and from other DICOM nodes.
- Check the availability of remote DICOM sites to receive file transfers.
- Drag images from the Patients List and drop them in the ***Communications*** window.
- Print to a high-resolution **DICOM printer**.
- Store and retrieve files in your **local archive**.
- Store and retrieve files in a **DICOM archive**.
- Query and retrieve patient demographic information from a **Worklist Broker**.
- Check and modify status of **DICOM operations**.
- Drag and drop to the **Recycle Bin** to delete selected items.
- Open the **Recycle Bin** to recover unarchived CR files.

Communications Toolbar



You can create and edit addresses and groups, perform query, retrieve and check site operations, and send images to a selected destination using the ***Communications*** window toolbar. When you click a button, the setting for that function is applied.

New Address

- Click **New Address** to open the ***Address Entry*** window, which allows you to enter information needed to communicate with other DICOM nodes. This is usually done by a system administrator. See the *System Administrator Reference Guide.*

New Group

- Click **New Group** to open the ***Group Setup*** window, which allows you to create groups of addresses. For more information about the ***Group Setup*** window, see Group Setup Window. This is usually done by a system administrator. See the *System Administrator Reference Guide.*

Query/Retrieve

- Click **Query/Retrieve** to open the ***Query*** window for an address selected from the ***Communications*** window. The ***Query*** window allows you to query remote DICOM nodes, DICOM archives, modality worklist brokers, and your local archive for files which you can retrieve to your local database. If no address is selected, **Query/Retrieve** appears dimmed. For more information about **Query/Retrieve**, see Query an AE , Query a Local Archive, To Query a DICOM Archive, or Query a Worklist Broker.

Check Site

- Click **Check Site** to determine whether a DICOM address selected from the ***Communications*** window is available for file transfer. If no DICOM address is selected, or the selected address is not a remote DICOM location, **Check Site** appears dimmed. For more information about **Check Site**, see Check a Remote DICOM Site.

Send

- Click **Send** to send a selected Patient Information, Study, Series, or Image to a selected destination. If there are no addresses *and* corresponding image files selected, **Send** appears dimmed. For more information about **Send**, see To Send Patients, Studies, Series, or Images.

DICOM Request Status

- Click **DICOM Request Status** to open the DICOM Request Status window—where you can check status or reprocess a DICOM request.

🟩- there are no postponed or failed requests

✸- there are rescheduling attempts

🛑 - one or more attempts have failed. For more information about DICOM Request Status, see DICOM Request Status.

Communications Right-Click Menu

The ***Communications*** right-click menu provides access to some of the ***Communications*** toolbar functions. For descriptions of the toolbar functions, see Communications Toolbar.

Checking a Remote DICOM Site

Use this feature to check a site's communication status before sending images to the site.

1. Select an Address **Nickname** from the ***Nodes*** list.

   - Click **Check Site**☑ on the ***Communications*** window toolbar. The selected remote site is checked for DICOM communications status and a message is displayed with that site’s availability.

     – or –

   - Select **Check Site** on the ***Communications*** window right-click menu. The remote site is checked for DICOM communications status and a message is displayed with that site’s availability.

Querying/Retrieving

Selecting a Node/Address

On the ***Communications*** window, you can select addresses (nicknames) on the ***Nodes*** list in any of the following ways:

- **Left-Click —** Provides the standard method of selecting a node. You can then apply a function from the toolbar or use the drag-and-drop feature to move the node to the **Recycle Bin**.
- **Right-Click —** Provides access to some of the toolbar functions for the selected node.
- **Double Left-Click —** Opens the ***Query*** dialog box for a selected *Worklist Broker*, *AE*, or *Local Archive* address nickname.

Allowing DICOM Retrieve Operations

You can set up KODAK General Radiography Software to allow retrieve operations of unprocessed images by other DICOM nodes. When another DICOM node retrieves from your local database, the status bar at the bottom of your screen shows the sending status.

To allow retrieve operations, make sure the target computer's ***Address*** with the corresponding **Retrieve AE Title** and ***Port Number*** is entered. Your computer's ***Address***, ***AE Title*** and ***Port Number*** may need to be in the target computer's Address Book.

Note: When you allow another DICOM node to retrieve images from your local DICOM node, KODAK General Radiography Software allows retrieval of only the unprocessed versions. If the user at the destination requires the processed version, the user must request that you manually send it to their DICOM node.

Querying Using Null Values and Wildcards

If your system supports wildcards, you can use null values and wildcards to define your query. Wildcards let you search for character patterns. You can:

- Use a null value (zero-length value) to return all entities for a selected query field.
- Use an asterisk (*) to match zero or more characters for a selected query field. For example: * returns all entities for a selected query field.
- *W** finds words that begin with *W*, such as *Wilson* and *Williamson*.
- Use a question mark (?) to match a single character for a selected query field. For example, *B?rt* finds four-letter words that begin with *B* and end with *t*, such as *Bart* and *Burt*.

Note: Your query results may vary depending upon the remote site you are querying.

Nodes

Query a Node

From your workstation, you can query a remote node to download patient images to your local database.

Query Dialog Box

- Double click a node in the Communications window to open the ***Query*** dialog box, which you use to query a node and download selected patient images to your local database.

– or –

- Select a node and click **Query/Retrieve** to open the **Query** dialog box.

Query Criteria

The ***Query*** dialog box contains query criteria that you use in combination with one another to refine your query results. You can also use null values and wildcards to define your query; see Querying Using Null Values and Wildcards.

- **Accession Number —** Patient visit ID, which you type using up to 16 text characters. The default value is null. This text box is case sensitive. Wildcards are not supported in the *Accession Number* text box.
- **Patient Name —** Name of the patient, which you type using up to 64 case-sensitive text characters. The default value is the wildcard character *.
- **Patient ID —** Identification number assigned to the patient, which you type using up to 64 case-sensitive alphanumeric characters excluding \ (backslash), ’ (apostrophe or single quote), and | (pipe). The default value is the wildcard character *.
- **Modality —** Type of radiography performed, which you select from a drop-down list.
- **Enable Date/Time —** When checked, enables a query to also be performed on the basis of date and time.
  - **Start Date/End Date —** The date range of the entries for which you want to query, which you select by clicking the arrows to choose a new date or by typing in a new value. The default values for *Start Date* and the *End Date* are the current system date.
  - **Start Time/End Time —** The time range of the entries for which you want to query, which you select from the drop-down lists. The default values for *Start Time* and *End Time* are 00 00 and 24 00.

Query

Click **Query** to query the **Node** with the values you entered on the ***Query*** dialog box.

Cancel

Click **Cancel** to cancel the query in progress, close the ***Query*** dialog box, and return to the ***Communications*** window without saving changes.

Query a DICOM Archive

From your workstation, you can query a DICOM Archive to download patient images to your local database.

Query Dialog Box

- Double click a **DICOM Archive Address Nickname** on the Nodes list to open the ***Query*** dialog box, which you use to query a DICOM Archive and download selected patient images to your local database.

  – or –

- Select a **DICOM Archive Address Nickname** and click **Query/Retrieve** to open the **Query** dialog box.

Retrieve From a Node

WARNING: When an image with processing or annotations is retrieved, the image is provided without including either the processing or the annotations.

Note: If the user at the remote viewing station would like to see the processed or annotated image, the user at the source station must send it to the remote station.

Note: When you retrieve files, KODAK General Radiography Software first reads available space on your local hard drive, then retrieves the selected files if there is enough space. If there is not enough free drive space, a message alerts you that the retrieve is cancelled. You should then archive and delete images to free up local drive space before attempting another retrieve.

KODAK General Radiography Software queries the Node and opens the ***Retrieve*** window, which displays a list of patients meeting your query criteria.

The ***Retrieve*** window displays patients from a Node (on the basis of your query criteria), that are available for retrieval into the acquisition and scanning program's database.

Accession Number
Patient Name
Patient ID
Modality
Date
Time
Study Description

The column headings on the ***Retrieve*** window correspond to the fields in the ***Query*** window. For more information on these fields, see Query a Node. Each column can be sorted by clicking the column name.

- Accession Number
- Patient Name
- Patient ID
- Modality
- Date
- Time
- Study Description

To import the Patient images to your local database:

1. Select the patient(s) you want to import. To make multiple selections, hold the **CTRL** key while clicking each item.
2. Click **Retrieve**. KODAK General Radiography Software retrieves the patient images, imports them to your local database, and closes the ***Retrieve*** window. The Patients list updates to reflect the retrieved records.

Note: If you attempt to retrieve a patient containing an invalid Patient ID format, a message alerts you that KODAK General Radiography Software will not accept the retrieval.

Archives

Retrieve From a DICOM Archive

Note: When you retrieve files, KODAK General Radiography Software first reads available space on your local hard drive, then retrieves the selected files if there is enough space. If there is not enough free drive space, a message alerts you that the retrieve is cancelled. You should then archive and delete images to free up local drive space before attempting another retrieve.

KODAK General Radiography Software queries the ***DICOM Archive*** and opens the ***Retrieve*** window, which displays a list of patients meeting your query criteria.

The ***Retrieve*** window displays patients, on the basis of your query criteria, from a ***DICOM Archive*** that are available for retrieval into the acquisition and scanning program's database.

The column headings on the ***Retrieve*** window correspond to the fields in the ***Query*** window. For more information on these fields, see Query a DICOM Archive. Each column can be sorted by clicking on the column name.

- Accession Number
- Patient Name
- Patient ID
- Modality
- Date
- Time
- Study Description

Note: Information displayed in the fields listed above depends on what is supported by the DICOM nodes.

1. To import the Patient images to your local database, select the patient(s) you want to import. To make multiple selections, hold the **CTRL** key while clicking each item.
2. Click **Retrieve**. KODAK General Radiography Software retrieves the patient images, imports them to your local database, and closes the ***Retrieve*** window. The Patients list updates to reflect the retrieved records.

Note: If you attempt to retrieve a patient containing an invalid Patient ID format, or an image which is already in your local database, a message alerts you that KODAK General Radiography Software will not accept the retrieval.

Query a Local Archive

From your workstation, you can query a Local Archive to download patient images to your local database.

Query Dialog Box

- Double click a the Local Archive node from the Communications window to open the ***Query*** dialog box.

– or –

- Select a **Local Archive Address Nickname** and click **Query/ Retrieve** to open the **Query** dialog box.

Retrieve From a Local Archive

Note: When you retrieve files, KODAK General Radiography Software first reads available space on your local hard drive, then retrieves the selected files if there is enough space. If there is not enough free drive space, a message alerts you that the retrieve is cancelled. You should then archive and delete images before attempting another retrieve to free up local drive space.

KODAK General Radiography Software queries the ***Local Archive*** and opens the ***Retrieve*** window, which displays a list of patients meeting your query criteria.

The ***Retrieve*** window displays patients, on the basis of your query criteria, from a ***Local Archive*** that are available for retrieval into the KODAK General Radiography Software database.

The column headings on the ***Retrieve*** window correspond to the fields in the ***Query*** window. For more information on these fields, see Query a Local Archive. Each column can be sorted by clicking on the column name.

Accession Number
Patient Name
Patient ID
Modality
Date
Time
Study Description

- Accession Number
- Patient Name
- Patient ID
- Modality
- Date
- Time
- Study Description

1. To import the Patient images to your local database, select the patient(s) you want to import. To make multiple selections, hold the **CTRL** key while clicking each item.
2. Click **Retrieve**. The program retrieves the patient images, imports them to your local database, and closes the ***Retrieve*** window. The Patients list updates to reflect the retrieved records.

Note: If you attempt to retrieve a patient containing an invalid Patient ID format, a message alerts you that the program will not accept the retrieval.

Worklist Brokers

Query a Worklist Broker

The modality worklist broker provides a DICOM interface with a hospital or radiology information system. From your workstation, you can query the worklist broker to download worklist information about scheduled procedures, arrived procedure status, and related patient demographic data.

Modality Worklist Dialog Box

- Double click a **Worklist Address Nickname** on the Nodes list to open the ***Modality Worklist*** dialog box, which you use to query a modality worklist broker and download selected patients to your local database.

– or –

- Select a **Worklist Address Nickname** and click **Query/ Retrieve** to open the **Query** dialog box.

Worklist Query Criteria

The ***Modality Worklist*** dialog box contains query criteria. You use these criteria in combination with one another to refine your query results. You can also use null values and wildcards to define your query; see Querying Using Null Values and Wildcards.

- **Accession Number —** Patient visit ID, which you type using up to 16 text characters. The default value is null. Wildcards are not supported in the *Accession Number* text box.
- **Patient Name —** Name of the patient, which you type using up to 64 case-sensitive text characters. The default value is the wildcard character *.
- **Patient ID —** Identification number assigned to the patient, which you type using up to 64 characters. The default value is the wildcard character *.
- **Modality —** Type of radiography performed, which you select from a drop-down list.
- **Start Date/End Date —** The date range of the worklist entries for which you want to query, which you select by clicking the arrows to choose a new date or by typing in a new value. The default values for *Start Date* and the *End Date* are the current system date in the format: mm/dd/yy.
- **Start Time/End Time —** The time range of the worklist entries for which you want to query, which you select from the drop-down lists. The default values for *Start Time* and *End Time* are 00 00 and 24 00.
- **AE Title —** Name of the application entity (typically the scanning station) for which you want to retrieve worklist entries and which you specify by typing up to 16 alphanumeric characters. The initial default value is your local AE title. *(Note: If your broker does not specify worklist entries by AE title, leave this field blank.)* This text box is case sensitive. Null values are supported in the *AE Title* text box; wildcards are not.

- **Procedure Status —** Status of the procedure, which you select from a drop-down list containing *Scheduled* and *Arrived.* The default value is null.
- **Performing Physician —** The name of the physician scheduled to administer the procedure, which you type using up to 64 text characters. The default value is the wildcard character *.

Set Default

Click **Set Default** (if you are an administrator) to save the currently displayed query values on the dialog box as your default values (with the exception of *Start Date* and *End Date*, which have no default values). These values display as your defaults the next time you open the ***Modality Worklist*** dialog box.

Query

Click **Query** to query the modality worklist broker with the values you entered on the ***Modality Worklist*** dialog box.

Cancel

Click **Cancel** to cancel the query in progress, close the ***Modality Worklist*** dialog box, and return to the ***Communications*** window without saving changes.

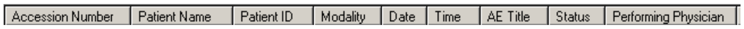
Retrieve From a Worklist Broker

Note: When you retrieve files, the program first reads available space on your local hard drive, then retrieves the selected files if there is enough space. If there is not enough free drive space, a message alerts you that the retrieve is cancelled. You should then archive and delete images to free up local drive space before attempting another retrieve.

The program queries the worklist broker and opens the ***Select Patients*** window, which displays a list of patients meeting your query criteria.

The ***Select Patients*** window displays patients, on the basis of your query criteria, from a worklist broker that are available for retrieval into the acquisition and scanning program’s database.

The column headings on the ***Select Patients*** window correspond to the fields in the ***Modality Worklist Query*** window. For more information on these fields, see Query a Worklist Broker. Each column can be sorted by clicking on the column name.



- Accession Number
- Patient Name
- Patient ID
- Modality
- Date
- Time
- AE Title
- Status
- Performing Physician

1. To import the Patient demographics to your local database, select the patient(s) you want to import. To make multiple selections, hold the **CTRL** key while clicking each item.
2. Click **OK.** The program retrieves the patient records, imports them to your local database, and closes the ***Select Patients*** window. The Patients list updates to reflect the retrieved records.

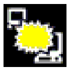
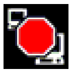
If you attempt to retrieve a patient from a worklist broker that already exists in your local database, a message asks you if you want your database to be overwritten with new information from the worklist broker.

Note: If you attempt to retrieve a patient containing an invalid Patient ID format, a message alerts you that the program will not accept the retrieval.

Appendix A: Troubleshooting

Possible Problem	Resolution/Explanation
Jammed film or plate	Ensure the scanner motor has stopped. If necessary, at the scanner, press Scan Abort. If the jam does not clear, refer to Section 3.0 System Operation of the Lumiscan LSDT Service Manual. If the jam still does not clear, call your certified service provider. Note: If you turn off and on the scanner you must wait at least five minutes before scanning.
Image Files Sent with Incorrect Compression	You can send images to other DICOM nodes in compressed or uncompressed formats. If an addressee is setup to receive lossy compression, a yellow triangle appears next to the nickname on the Communications Window.
Image Processing Failure	If an Image Processing Warning appears, contact your system administrator, or, CR system representative if you are an administrator, describe the failure and give them the name of the selected process that failed and the accompanying error code.
Improper Image Acquisition: Host PC Too Busy	To ensure adequate system performance, an administrator must configure your system with the minimum hardware and software as specified in the Hardware Compatibility List furnished with the KODAK General Radiography Software.

Possible Problem	Resolution/Explanation
Improper Image Orientation	Review each scanned image and, as necessary, use the following functions to orient the image properly. Flip Vertical - Click this button to flip an active image vertically. Flip Horizontal - Click this button to flip an active image horizontally. Rotate Left - Click this button to rotate an active image 90^o left. Rotate Right - Click this button to rotate an active image 90^o right.
Unable to store images	Ensure that your image directory resides on your local hard drive; otherwise, a network failure prevents you from accessing remotely stored images.
Incomplete image acquisition due to improper data control board (DCB) settings	Scanner DCBs have on-board RAM that temporarily stores the scanned image before the KODAK General Radiography Software retrieves it. Your certified service provider must validate the DCB settings after the KODAK General Radiography Software installation as well as after installation or upgrade of the DCB.
Images Sent to Wrong Destination	Ensure the target computer’ s address with the corresponding Send/Receive AE Title and Port Number is entered on the Address Entry Dialog Box. Ensure the sender’ s address is in the target computer’ s Address Book. Drag the correct image(s) from the Patient list and drop it into the address in the Communications Window.
Transmission failure	Open the events log to view which DICOM node failed transmission. Perform a *Check Site* to ensure the remote site is available for receiving images. If the remote site is not available, contact the remote site personnel to determine availability.
Repeated transmission failure	Ensure that you are using a unique patient ID when sending to another DICOM node. Contact the remote site personnel to determine if they are having a database conflict due to duplicate file information.

Possible Problem	Resolution/Explanation
Repeated transmission failure to a specific destination	If you are experiencing repeated transmission failure to a specific destination: 1) Perform a *Check Site* to determine the DICOM availability of the remote location. 2) Contact the remote site personnel and verify they have your workstation' s IP or DNS address, AE Title, and Port Number in their local address book and that they permit the type of DICOM operation you are attempting.
Communications Window Toolbar displays: ***Rescheduling attempts***  ***One or more attempts have failed*** 	Click the DICOM Request Status button to display the DICOM Request Status window and do one of the following: • Wait for the system to reattempt the request • Clear the request • Reprocess the request 1) From the DICOM Request Status Window, select the request from the list. To make multiple selections, hold the **CTRL** key while clicking each item. 3) Click one of the following buttons: • **Clear All Requests** —clears all pending requests • **Clear Request** —clears the request • **Reprocess Request** to reprocess the selected requests

Appendix B: Warnings

The following warnings are intended to prevent any potential patient or operator safety hazards. Please read them carefully.

WARNING
It is highly recommended that you • Periodically perform preventive maintenance of your local hard drive(s) using Windows 2000 Administrative Tools to reduce the chances of disk crashes. • Frequently archive all data on your hard disk to avoid data loss in the event of a hard disk crash. • Periodically check your local storage device(s) and media for defects to reduce the chances of data corruption.
The DICOM and Windows printing capability is intended for reference only and not for diagnosis.
The technician must ensure proper orientation of the image prior to saving or sending. The diagnosing physician must make sure the scanned image is oriented properly before making a diagnosis.
The Read/Unread feature is intended to be used only by the diagnosing physician. Use care when marking images with Read/Unread.
Run the Self-Test regularly to ensure acceptable ACR-2000 performance.
Stopping the scanner or pressing the Scan Abort button results in lost CR plate content and may result in an improper image acquisition or a lost image.
Images scanned on the ACR-2000 scanner at 1K (1024 pixels/line) or lower resolution may not be of diagnostic quality.
Jammed films or plates could cause improper image acquisition.
If you manipulate or process images while synchronization is on, images could be affected that are currently not being viewed on the screen.

WARNING
Ensure the correct match has been found for the Accession number while using the Scan Wizard; otherwise, you could have the incorrect patient information.
The displayed image (during the Scan Wizard) is intended for ensuring correct image orientation and not for diagnosis.
Annotations/measurements are for reference only and are not intended for diagnostic use.
Image processing applied to images not acquired with an ACR-2000 may result in non-diagnostic quality images.
Improper equipment operation may result in injury to personnel due to the laser. All digitizer users must be trained in the proper operation of equipment by certified service providers.
Improper installation, hardware configuration, and maintenance could result in improper image acquisition or lost images.
KODAK General Radiography Software is optimized to run across local area networks (LANs). If sending patient records to your selected destination requires the use of a wide area network (WAN), you may experience transmission difficulty due to the inherent unreliability of WANs. You should contact the remote site to verify they received the expected patient records and resend if necessary.
All images must have patient identification burned into the image at the time the x-ray is taken.
KODAK General Radiography Software is not intended to be used for primary diagnosis of received images.
When an image with processing or annotations is sent, the image pixel data is modified to include any processing and annotations. Once the image is received at the remote station, the processing and annotations cannot be removed from the image.
When an image with processing or annotations is retrieved, the image is provided without including either the processing or the annotations.
Configure the monitor for square pixels; otherwise, the image aspect ratio could be incorrect.
Lossy-compressed images may not be of diagnostic quality. Compressed files take less time to transmit, but lossy compressed files result in data loss and lower image quality.

Kodak

http://www.kodak.com/go/health (800) 328-2910

CD PowerPACS™

(CD POWERPACS)

USER MANUAL

Version Number

1.x

A DICOM Image
Write-to-CD/DVD Program

C-TM-000 xxx-00

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RADinfo SYSTEMS™
2411 Dulles Corner Park
Suite 140
Herndon VA 20171
703-713-3313 Voice
703-713-3343 Fax
www.radinfosystems.com

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D. Standards & Conventions

1. Typographical Conventions

Various typographical standards exist throughout this manual series to assist readers. These are as follows:

?? *Italicized text* draws attention to an important point or an item of special interest.
?? **Smaller and bold text** refers to items appearing on the monitor display, such as screen buttons or menu selection items. When used to indicate a selection string, the individual items are separated by the "|" character, as in the **File | Open** string.
?? `Monospaced text` refers to sequences that must be typed or entered–exactly as listed in manual text – using keyboards, keypads, touch-screens, or similar entry devices.
?? **`Bold Monospaced Text`** refers to file names , directory names, program files, library names, or similar references to programming structures.
?? <RETURN> refers to the entry method used to enter data or indicate the end of a typed line. Various systems alternately refer to this as <NEW LINE> or <ENTER>. These terms are interchangeable.

2. Notes, Cautions & Warnings

a. Notes

Notes provide important information to the reader. Notes emphasize or clarify key points. The general format for a Note follows.

NOTE

> This is an example of a note. Note text consists of blocked, indented margins and uses the normal (roman) font.
>
> Notes provide important information to the reader. Notes emphasize or clarify key points.

b. Caution

Cautions indicate potential hazards associated with equipment use or operations. Failure to observe cautions can result in *minor to moderate* personnel injury or property damage. The general format for a Caution follows.

CAUTION

> *This is an example of a caution. Caution text consists of blocked, indented margins and uses an italic font.*
>
> *Cautions indicate potential hazards associated with equipment use or operations. Failure to observe cautions can result in minor to moderate personnel injury or property damage*

c. Warning

Warnings indicate that a specific hazard is known to exist with equipment use or operations. Failure to observe warnings will result in *severe to fatal* personnel injury or substantial property damage. The general format for a Warning follows.

WARNING

> ***This is an example of a warning. Warning text consists of blocked, indented margins and uses a bold-italic font.***
>
> ***Warnings indicate that a specific hazard is known to exist with equipment use or operations. Failure to observe warnings will result in severe to fatal personnel injury or substantial property damage.***

3. Revision History

Revision	Date	Reason for Change
DRAFT	15 FEB 2001	DRAFT FOR COMMENTS
PRELIM	30 APR 2001	PRELIMINARY RELEASE
RELEASE	26 MAY 2001	INITIAL RELEASE

4. Errors, Feedback, or Comments

Please report any errors or provide feedback or comments to RADinfo Systems at the address given on page ii of this manual.

5. Safety

Observe appropriate electrical safety precautions whenever using the CD *Power*PACS workstation. Never insert or remove connectors with power applied to the workstation. Do not operate the workstation when it is wet.

The CD *Power*PACS workstation is configured at the factory for optimal performance. Do not load–or alter–software or drivers without the express permission and authorization of RADinfo Systems.

Chapter 1 OVERVIEW

A. Introduction

This manual provides users –Clinicians, Technologists, Administrators, and Physicians –with information necessary to understand and operate the RADinfo Systems CD *Power*PACS workstation and software.

CD *Power*PACS is an integrated application suite that permits users to quickly locate DICOM Studies, Series, and Images on compatible, configured, networked devices. Once located, CD *Power*PACS software permits identifying, organizing, pre-viewing, and selecting DICOM images for inclusion into a storage set. The workstation then writes storage sets to CD/DVD media.

NOTE

> The images included in storage sets are copied from their original locations. CD *Power*PACS does *not* erase or delete images from their original storage locations.

B. Purpose

A RADinfo Systems CD *Power*PACS Workstation facilitates locating, organizing, and duplicating DICOM Studies, Series, and Images onto removable storage media (e.g., compatible Microsoft Windows ? CD or DVD media). CD *Power*PACS also installs a DICOM viewer (CD *Power*PACS Viewer) onto this media at time of creation. Thus, the media created provides a transportable *duplicate* of the original DICOM image(s), along with operational DICOM viewing software. Thus, patients can transport radiological studies and view them using virtually any Microsoft Windows ? personal computer, without the need for CD *Power*PACS, or any additional software. CD *Power*PACS also prints content information (unique patient identification) on the face of the CD.

C. Basic Operations

CD *Power*PACS software is pre-loaded into a desktop workstation. The pre-configured workstation is shipped directly to the customer as a plug-and-play device. The workstation attaches to a local area network (LAN), which provides connectivity necessary to obtain images from other DICOM modalities, servers, and workstations.

The CD *Power*PACS workstation includes an internal or an external CD/DVD writing-device. (The manufacturer, model, configuration, capabilities, and capacity of the CD/DVD writing device vary according to customer specifications.) This device places (writes) storage sets onto the designated media. In addition, a CD *PowerPACS Viewer* DICOM viewer is optionally placed on each piece of media. Depending on the specified configuration, simultaneous media creation is possible, with each piece of media receiving a uniquely printed label, which contains meaningful descriptions of the storage set images.

D. Functions

*CD Power*PACS software permits users to perform various functions. The following list presents these in a manner roughly approximating the operational sequence in which they would be used in a typical working environment:

?? Locate DICOM images.

    ✍✍Search local storage devices.

✍✍ Search authorized networked storage devices.

✍✍ Automatically operates in the background.

?? Receive DICOM images using DICOM C-STORE SCP.

✍✍ Automatically receive DICOM images from authorized devices.

✍✍ Automatically runs in the background.

?? Retrieve DICOM images, using DICOM C-GET.

✍✍ Manually retrieve DICOM images from authorized devices.

✍✍ Copy DICOM images from the originating device to local storage.

?? List DICOM images.

✍✍ List all DICOM images.

✍✍ Arrange images according to storage devices.

✍✍ Sort images according to user-defined preferences.

?? Organize and Sort DICOM images according to:

✍✍ Patient.

✍✍ Study.

✍✍ Series.

?? Display DICOM images. (Optional)

?? Create image archives (storage sets):

✍✍ Select images for inclusion.

✍✍ Create multiple storage sets.

✍✍ Manually begin archival process.

?? Archive DICOM Images to CD/DVD media.

?? Label media with unique, meaningful identifiers. (Optional)

✍✍ Patient Name.

✍✍ Patient ID.

✍✍ Study Date.

✍✍ Study Description.

?? Manage local storage volume.

✍✍ Automatically delete images and storage sets according to user-defined criteria.

E. Capabilities

Operationally, a *fully configured* CD *Power*PACS workstation is capable of:

?? Connecting to all DICOM workstations in the network.

?? Copying DICOM Studies, Series, and Images at the data rate supported by the DICOM network.

?? Creating multiple storage sets, each up to the capacity of the selected storage media.

?? Queuing multiple storage sets in preparation for writing to media, according to the specification of the CD/DVD writers.

?? Writing multiple images to media devices, simultaneously.

?? Storing 120 pieces of blank CD/DVD media online.

?? Printing unique identification on each piece of CD/DVD media.

?? Placing a DICOM viewer onto each piece of media, automatically.

NOTE

> The capabilities of an individually configured CD *Power*PACS workstation vary according to specifications given by the customer. The capabilities listed are typical of a standard configuration.

F. System Overview

Because CD *Power*PACS is a small part of an integrated imaging system, examining system workflow provides a good starting point for understanding functionality. Refer to Figure 1 -1, a basic block diagram of the CD *Power*PACS Workstation within a system.

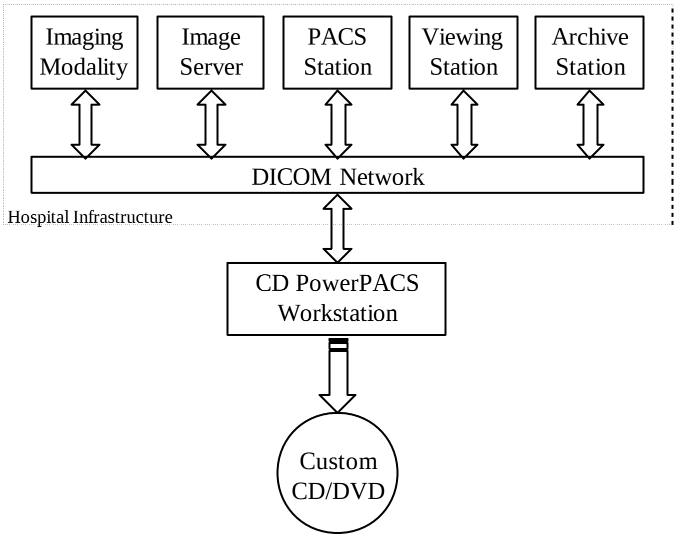

Figure 1-1 CD *Power*PACS Workstation Within a System

DICOM images exist within a hospital infrastructure on various device types. In this illustration an Imaging Modality, an Image Server, a PACS Station, a Viewing Station, and an Archive Station represent these different devices. Regardless of the device, an existing DICOM Network provides connectivity and communications between devices, allowing DICOM image transfers between devices.

The CD *Power*PACS Workstation arrives pre-configured with appropriate DICOM connectivity information and directly attaches to the existing DICOM Network. When connected, the CD *Power*PACS Workstation queries DICOM devices and creates a list of available DICOM Studies, Series, and Images. Users select the desired DICOM device, obtain a list of Studies, Series, and/or Images available for that device, and review this list to determine which items to include in a storage set. Individually selected images are copied to the CD *Power*PACS Workstation; the original image remains on the source device. The storage set of images is automatically written to CD or DVD media, along with a DICOM viewing program.

Depending on the selected options, the CD/DVD media receives a custom label indicating key demographic information. The media is transportable and provides a means to view images on any compatible Windows personal computer.

G. Specifications

The CD *Power*PACS Workstation complies with DICOM standards and provides user and network security to ensure patient confidentiality. The CD *Power*PACS Workstation contains hardware (PC Workstation and media writing device) and software components. Refer to Page 74, APPENDIX D: HARDWARE & SOFTWARE REQUIREMENTS, for a complete description of each CD *Power*PACS standard configuration.

1. DICOM Networking

CD *Power*PACS Workstation complies with DICOM 3 and TCP/IP networking standards. Therefore, when installed into an existing hospital network, each workstation requires the Net work System Administrator to assign several unique identifiers prior to installation. These values, which remain unchanged throughout the life of the installation, include:

?? TCP/IP address.
?? TCP/IP Port Number
?? Host Name.
?? AE Title.

In addition, a plain -text Description field permits workstation identification on a more easily identifiable level.

2. Hardware

Generic CD *Power*PACS Workstation specifications are given in the following list.

Item	Vendor	CD *Power*PACS System
OS	Microsoft	Windows 2000 or Windows NT 4.x
Processor	Intel	Pentium III
Speed	MHz	≥700
Cache	L2	512 kB
Memory	Generic	128 MB
Hard Disk Storage	Seagate or equivalent	≥20 GB
Case	Generic	Mid or Tower
Media 1	Generic	3-1/2"
Media 2	Generic	2x-4x-24x CD
Video	Diamond Stealth or ATI/Rage	≥16 MB Onboard RAM
Monitor	Generic	15" SVGA 1280x1024 @75Hz
Modem	3COM/USR	V.90, 56k
NIC	3COM/USR	10/100 BaseT Ethernet (RJ-45)
Keyboard	Generic	Yes
Mouse	Generic	Yes w/ Wheel
Remote Access	Symantec	pcANYWHERE 9.x
Media Writing Device	Generic	Varies by Configuration

Optional, but recommended, ancillary devices are given in the following list.

Item	Vendor	Description
UPS	APC	650 VA or greater
Surge Strip	Generic	3-prong with overload protection

3. Software

Minimum software specifications for a complete CD *Power*PACS Workstation are as follows:

?? Microsoft Windows 2000, or NT 4.x with SP6.
?? Remote Session Software
  ✍✍Windows 2000 Remote Access Server.
  ✍✍NT Remote Access Server.
?? TCP/IP Drivers and stacks.
?? CD *Power*PACS Application.
?? Media writing device drivers.
?? pcANYWHERE is optionally required for remote maintenance and diagnostics.

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Chapter 2 CD *Power*PACS WORKSTATION INSTALLATION

A. Introduction

After obtaining configuration information during a site survey, the CD *Power*PACS Workstation is pre-configured at the factory. Typical on-site hardware installation consists of unpacking the workstation and attaching power and interface cables. Testing at the end of each phase of installation ensures success.

B. Site Survey

The installation process begins with a site survey. This survey gathers and verifies information unique to your site. The most important information determined during this survey is:

?? The physical location for the CD *Power*PACS Workstation.
?? Availability and adequacy of site power.
?? Availability and adequacy of ventilation (air flow and cooling).
?? Availability and adequacy of communications interfaces, including:
✍✍The network into which the workstation connects.
? ? IP Addresses.
? ? Host Names
? ? AE Titles.
? ? Port Numbers.
✍✍Broadband digital communications interfaces and devices.
? ? Network diagram.
? ? Bridges, routers & hubs.
? ? Firewalls.
✍✍Analog telephone lines (for remote diagnostics and servicing).
? ? Direct (No Centrex, PBX, or other switching devices).
? ? Dedicated.
? ? Available bandwidth.
? ? Unrestricted Dial-out and Dial-in capability.
? ? Prefix and/or suffix dialing information.

APPENDIX C: SITE SURVEY WORKSHEET, located on Page 72, provides a sample of the Site Survey worksheet.

1. Equipment

The basic CD *Power*PACS Workstation consists of a processor (computer), a media writing device, a monitor, a keyboard, and a mouse. Depending on the specified configuration, the CD/DVD media-writing device may be either an internally- or externally-housed unit. The media device selected for your unique configuration affects all parameters —especially the footprint and weight of the workstation. In addition, the workstation may optionally include an Uninterruptible Power Supply (UPS). The approximate weights and dimensions of major components are listed in the following table.

Item	Weight (Lbs.)	Dimensions (Inches)
Processor	15	18 x 8 x 18
Monitor	30	16 x 15 x 18
Keyboard	1	20 x 6 x 2
Mouse w/ Pad	0.25	6 x 8
UPS	40	8 x 12 x 18
Media Writer	Varies by Device	

2. Location

The CD *Power*PACS Workstation must be placed in a location suited for its intended functions. The perspective location must have sufficient free volume to accommodate each item. The location must provide additional clearance for cables and provide sufficient cooling (ventilation). In addition, the location must accommodate the weight of the components. Finally, the location must provide sufficient space for operators to access and use the equipment without interference.

3. Environment

The workstation should be in a clean, air-conditioned room. There should be enough airflow around the workstation to ensure dissipation of internal heat. If possible, do not locate the workstation on the floor. In particular, for cleanliness reasons do not place the workstation on carpets or in corners. Similarly, do not place the workstation near fire sprinklers.

Do not operate the workstation at temperatures below freezing, or above 120 °F. Do not operate the workstation during conditions of excessive humidity, or when there is a possibility of condensation.

Avoid locations with fumes or airborne chemicals, such as might be found in the vicinity of film processors.

4. Power

Workstation processor power should come from a conditioned, regulated, isolated, and protected source– such as an UPS. An UPS stabilizes power through grid disruptions, protects the processor, protects the workstation database, and provides automatic, graceful workstation shutdown. The hospital's protected (emergency) power source is next most desirable source. At a minimum, route all workstation component power through a surge protector.

Mark designated power outlets as **RESERVED** at the time of the site survey. Ensure all equipment connected to the workstation receives power from the same source; this prevents the possibility of circulating currents and ground loops. Do not route workstation power through multiple extension cords or ganged-outlets. It is highly desired that site facilities verifies phasing and measures AC and DC volts-to-ground to determine that these are within acceptable limits.

5. Cables and Connections

Communications cables and connectors are a frequently overlooked aspect of workstation preparation and installation. The following items assist in satisfying these needs.

It is important to properly determine cable lengths. Routing cables across a room increases the length of the cable run; consider vertical drops and rises as well as horizontal distances. Keep cables off the floor to avoid trip hazards and damage. To the extent possible, do not route cables across or behind desktops; do not permit cables to hang freely.

a. Network Connection

The CD *Power*PACS Workstation comes with a Network Interface Card (NIC) and a Category 5 (100 MBPS) connection cable. This permits bi-directional communications with Imaging Modalities, DICOM Workstations, PACS, and other devices. The NIC has an RJ-45 network connector and auto senses 10- or 100-MBPS Ethernet.

Locate the workstation as closely to the network drop as possible. Label the network drop with the appropriate TCP/IP address and mark it as **RESERVED**. Test the network drop and connecting cables prior to workstation installation. Ensure the data throughput is adequate for image routing, and that the anticipated image traffic does not disrupt network operations.

Ensure all network cables and connectors conform to Category 5 standards for 100 MBPS Ethernet or to Category 3 for 10 MBPS Ethernet. Minimize the length of cable joining the network drop and the workstation NIC; never coil, bend, twist, or kink this cable.

Obtain and record the following items for the CD *Power*PACS Workstation and for all workstations communicating with the CD *Power*PACS Workstation:

?? Workstation unique identifications.
  ✍✍TCP/IP address.
  ✍✍Host Name.
  ✍✍Port Number.
  ✍✍AE Title.
?? Additional protocol stacks required for this network.
?? Complete network routing and masking information – including all Gateways, Routers, and Bridges – between the CD *Power*PACS Workstation and other imaging workstations.
?? System Administrator’s name & phone number.

b. Phone Connection

When applicable, the CD *Power*PACS Workstation includes an internal analog modem that requires an external phone line connection. (The modem provides remote diagnostic, upgrade, and maintenance capability.) A standard phone cable is six feet long; thus, the workstation is usually within six feet of the phone drop.

Successful bi-directional communications requires a direct connection to the TELCO point of demarcation, not a route through the hospital switch or PBX. The connection should be capable of receiving direct dial in and sending direct dial out. Ensure there are no long-distance or area code limitations on outgoing calls. Test the phone line (multi-frequency line sweep) to determine line quality *prior to* workstation installation and on a regular basis thereafter.

Please obtain and record the following items:

?? Phone number with area code – this number should be written on the wall plate.
?? Special prefix/suffix dialing codes.
?? Local TELCO name with repair service number.
?? Hospital Phone Services Administrator name and phone number.

NOTE

> RADinfo Systems pre-configures outward dialing according to information determined during the initial survey. Due to the multitude of phone dialing and routing combinations, all dial-out phone destinations must be verified, tested, and validated at time of workstation installation. Where necessary, pre-installed configurations must be adjusted for various combinations of prefix (9), long distance access (1+), area code (xxx), long-distance access (yyy), and internal accounting (zzz).

C. Equipment Installation

The CD *Power*PACS Workstation arrives pre-configured with the information gathered during the site survey. The accuracy and completeness of this information determines the degree of "plug-and-play" success. In most instances, remaining equipment installation tasks involve unpacking the workstation and attaching a few connectors.

1. Unpacking

Prior to unpacking workstation components, check the shipment against the packing list to ensure all boxes arrived. Also verify that containers are not damaged. Immediately document and report to the carrier any missing boxes or evidence of damage; then contact RADinfo Systems for additional instructions. Do not proceed with equipment installation until all workstation components are available and in acceptable condition.

Unpack the equipment in the following order:

?? UPS (if part of system).
?? Surge Protector.
?? Processor.
?? Monitor.
?? External Media Writing Device

NOTE

> Inventory the shipment before opening any of the boxes. Carefully open each box and carefully remove its contents. Keep all packing materials onsite until the installation is satisfactorily completed.
>
> Each manufacturer provides separate warranty, installation, and operation documents. These should be gathered into a central location and retained for future reference.

2. UPS Installation

Refer to the UPS manual and follow the manufacturer's INSTALLATION and TEST procedures. Contact RADinfo Systems for additional instructions if these tests fail.

CAUTION

Ensure the UPS battery charges for at least 24 hours prior to use in a system. Failure to comply with this requirement reduces battery life and shortens the time the UPS can ride-through power outages.

Connect the surge protector to the designated wall outlet. Check available indicators to ensure there are no electrical problems.

CAUTION

Never connect the surge protector to an extension cord or through another surge protector. Do not connect a surge protector to the outlet of an UPS.

3. Computer (Processor/CPU)

Follow the manufacturer's instructions and unpack the processor. Carefully remove the processor from its protective carton. Note any damage. Remove the keyboard and mouse from their shipping boxes and connect these to the processor. Connect the processor power cord to the UPS (if available) or to the surge protector. Keep all documentation and packaging materials for future reference.

NOTE

Contact RADinfo Systems prior to installing the automated shutdown software associated with the UPS, or prior to installing cables between the UPS and the workstation.

4. Monitor

Follow the manufacturer's instructions and unpack the monitor. Note any damage. Connect the monitor power cord to the surge protector. Due to UPS capacity limitations, do not connect the monitor to the UPS. Connect the video cable to the processor. Keep all documentation and packaging materials for future reference.

5. Initial Workstation Power Application

Apply power to the monitor and then to the processor. The workstation should start normally and advance to the Windows Logon screen. If it does not, turn off the equipment. Check power and video cable connections. Contact RADinfo Systems if you are not able to resolve this problem. Do not continue with equipment installation until the workstation boots properly, as indicated by the Login and Password screen.

During this initial startup sequence, the workstation will indicate various communications errors because interface cables are not attached; this is normal for this portion of the installation process.

6. External Media Writing Device

Follow the manufacturer's instructions and unpack the device. Note any damage. Connect the device power cord to the surge protector. DO NOT connect the device to the processor at this time. Keep all documentation and packaging materials for future reference.

7. Interface Cable Installation

Connect cables to external devices and services only after successfully booting the standalone workstation. Verify each service functions correctly before continuing to the next service.

a. SCSI Cable & Terminator

A Small Computer System Interface (SCSI, pronounced "scuzzy") joins the workstation and the external media-writing device. The SCSI standard requires installation of a cable and a terminator. SCSI connections must be performed while equipment is OFF.

CAUTION

> *Attempting to connect or disconnect SCSI cables with power applied can cause serious damage to SCSI components. The nature and extent of the damage varies; the general result is equipment failure.*

The SCSI cable is between three- and six-feet long. Cable connectors vary, depending on the devices used. The cable is stored in a package in the media writing device box. Mate each end to its appropriate receptacle in the workstation and the media-writing device. Ensure they are properly seated and affixed.

Some configurations require a SCSI terminator, a small rectangular device. This device fits into the second receptacle found at the back of the media-writing device.

NOTE

> SCSI devices do not function correctly unless they are properly terminated. Failure to install the terminator can result in intermittent system failures.

b. Network Cable

The network cable resembles a telephone cable. Network cables differ from phone cables in three significant ways. The plastic connector is: twice as wide; has eight wire fingers; and, the cable is thicker and stiffer.

Connect one end to the network drop previously reserved for this purpose. Connect the other end to the Network Interface Card (NIC) at the rear of the workstation. Status lights on the NIC activate to indicate a good electrical connection.

NOTE

> Status light illumination does not guarantee data passes over the network. This only indicates good physical and electrical contact.

Shutdown and restart the workstation. Use the appropriate **NETWORK** Icon on the desktop to verify communications with other workstations on the network. Contact your network administrator for more information, or if you experience difficulties. RADinfo Systems is available to assist as necessary.

c. Modem Cable

The modem cable resembles a standard telephone cable used in homes. Some modem cables come with a metallic "doughnut" at one end. This end should be attached to the workstation outlet labeled TELCO, LINE, or WALL. Connect the other end of the cable to the designated wall jack.

Alternatively, most surge devices provide protection for a single phone line. If desired, route the modem cable from the workstation to the surge protector. A second modem cable, located in the surge protector box, needs to be routed between the surge protector and the wall plate.

D. Testing

After installing all interface cables, start the external media-writing device. Wait 90-seconds and restart the workstation.

Complete the Windows login. The workstation should automatically:

?? Connect to the hospital network.
?? Launch CD *Power*PACS.
?? Initialize the Media writing device.
?? Open the CD *Power*PACS LOGIN window.

Enter the default LOGIN ID and password provided on your sales order or obtained from RADinfo Systems Technical Support. Successfully launching the application indicates all software interfaces are operating nominally.

E. Remote Diagnostics

Contact RADinfo Systems to setup and test the remote diagnostic connection. CD *Power*PACS Workstations specifying this feature on the sales order leave the factory with remote diagnostic software installed. RADinfo Systems Technical Support will schedule the initial connection and configuration to coincide with the installation.

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Chapter 3 OPERATING THEORY

A. *Simplified Workflow Between Components*

A basic description of workflow appeared in Chapter 1 of this manual and is reproduced as Figure 3-1. Recall that the CD *Power*PACS Workstation received data from the Hospital Infrastructure and displayed this data to permit creating the storage sets used to place images on media. Representative details of this normal workflow sequence are now presented for a *typical* Hospital environment; specific details vary by location.

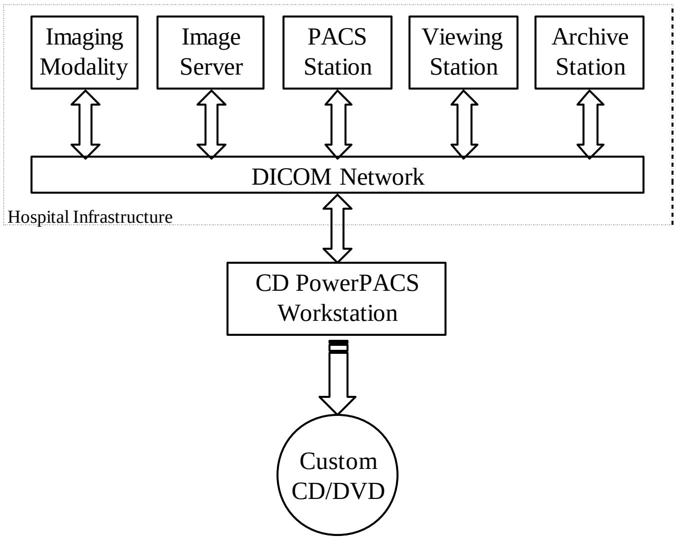


Figure 3-1 System Data Flow

Typically, workflow follows a standard sequence:

?? Order Creation.
?? Image Creation.
?? Processing by Imaging Modality.
?? DICOM Network Operations.
?? CD *Power*PACS Workstation Operations.

B. *Order Creation*

Orders begin when physicians write an order for a study. After the order is generated and entered into the Hospital's information system, several administrative tasks are performed in the background. These tasks include:

?? Necessary data is automatically gathered from the HIS/RIS (Hospital Information System/Radiology Information System) database or manually entered directly into the RIS order system.
?? RIS assigns a unique study identifier (Study Instance UID).
?? RIS assigns a unique order identifier (Accession Number).
?? The system administrator reviews, manipulates (adds/changes), and validates mandatory data fields as necessary.
?? Additional data fields identify specific study requirements.
?? The completed, validated order appears at the Imaging Modality.

C. Image Creation

After the order appears on the Imaging Modality’ s display, several steps occur prior to image creation. Technologists review patient orders and perform the indicated studies after completing these steps, which include:

- Selecting the desired order from the local work list/database.
- Validating the order against available resources.
- The study proceeds after validation.

When the patient arrives, study information (image data and patient demographics) receives processing according to either of two standards. The modality is —or is not—DICOM conformant. DICOM conformance does not impact performance of the actual study, only the manner in which the completed study continues processing.

- DICOM Modalities:
  - Automatically place all required and appropriate DICOM information in image headers.
  - Create digital images in conformance to DICOM standards.
  - Organize images according to Studies, Series, and Images.
- Non-DICOM Modalities:
  - Create images in proprietary formats.
  - May provide information in image headers, if this option is available.
  - May, or may not, organize images according to Studies, Series, and Images.
  - Require intermediate format conversion to comply with DICOM standards.

Regardless of the method of image creation, DICOM Studies, Series, and Images route to appropriate destinations via a network. The DICOM source may send the Studies, Series, and Images to a single destination or to multiple destinations. Such destinations may be either a final or an intermediary destination. (For example, a Quality Assurance (QA) Workstation is an intermediary destination in which images are held until validated. After validation, images route to other destinations.)

D. Imaging Workstations

Imaging workstations receive DICOM images in order to accomplish certain functions. These devices vary according to the functions performed. Typically, these include:

- QA Workstations.
- Image Servers.
- PACS Workstations.
- Viewing Workstations.
- Archive Workstations.

Regardless of the functions performed by the specific workstation, these DICOM devices follow rules that allow communications with the CD *Power*PACS Workstation. These rules permit workstations to:

- Receive, process, store, and distribute DICOM Studies, Series, or Images.
- Automatically forward copies of Studies, Series, or Images to the CD *Power*PACS Workstation.
- Automatically service DICOM queries originating at the CD *Power*PACS Workstation.
- Send identical, duplicated, digital copies of DICOM Studies, Series, or Images while retaining the original Studies, Series, or Images.

E. CD *Power*PACS Workstation (Network Operations)

When connected to the hospital network, the CD *Power*PACS Workstation accomplishes both automated and manual tasks.

The CD *Power*PACS Workstation accomplishes automated tasks in the background in response to incoming traffic, or in response to internal timers. The Workstation automatically receives DICOM Studies, Series, and Images from authorized workstations whenever they are sent. In addition, the CD *Power*PACS Workstation periodically queries DICOM workstations to obtain a list of available Studies, Series, and Images. Because of security considerations, the CD *Power*PACS Workstation only acknowledges—and responds to—communications with workstations identified and authorized in its local configuration. These automatic communications include:

?? Automatically receiving copies of DICOM images from authorized, connected imaging workstations and storing these on the local hard disk.
?? Automatically generating and displaying a list of studies, organized by connected imaging workstations.
?? Automatically organizing and sorting all DICOM images according to Imaging Device, Patient Name, Study, Series, and Image.
?? Automatically copying selected DICOM images from authorized, connected imaging devices to local hard disk storage.

The CD *Power*PACS Workstation immediately queries networked workstations in response to real-time operator commands. The process is identical to the automated task, except for the method of initiation.

?? Manually initiating DICOM Query to obtain a list of Studies, Series, and Images from networked workstations.
?? Automatically generating and displaying a list of studies, organized by connected imaging workstations.
?? Automatically organizing and sorting all DICOM images according to Imaging Device, Patient Name, Study, Series, and Image.
?? Automatically copying selected DICOM images from authorized, connected imaging devices to local hard disk storage.

F. CD *Power*PACS Workstation (Local Operations)

The CD *Power*PACS Workstation places DICOM images on removable, transportable storage media. The process begins by gathering and displaying a list of DICOM Studies, Series, and Images available on the network. The CD *Power*PACS software organizes and creates a list of the Studies, Series, and Images. Operators select images and create storage sets from the list of available images. The CD *Power*PACS software automates and controls the media creation process.

Sequentially, specific tasks accomplished in this process include:

?? CD *Power*PACS generates and displays a list DICOM Studies, Series, and Images.
?? Operators review the list of Studies, Series, and Images and create storage sets to place on media.
?? CD *Power*PACS automatically writes DICOM Studies, Series, and Images to selected CD/DVD media.
?? CD *Power*PACS optionally places a CD *Power*PACS Viewer application on the media.
?? CD *Power*PACS automatically buffers (stores) additional storage sets when requests for media-creation exceed the capacity of the workstation.
?? CD *Power*PACS automatically prints a unique identifying label on each piece of CD/DVD media created. (Optional equipment required.)
?? CD *Power*PACS manually or automatically removes (purges) images from the local hard drive according to configurable rules.

NOTE

CD *Power*PACS operation is separate from the operation of other imaging workstations. This section illustrates the roll of the CD *Power*PACS in overall workflow; it is not a substitute for individual equipment operation instructions.

Chapter 4 SOFTWARE FAMILIARIZATION

A. *Overview*

The CD *Power*PACS Workstation automatically launches the CD *Power*PACS software application at startup. The software initially opens to display the Startup Screen & Login Window. This provides operational security and helps to ensure patient confidentiality. After entering appropriate login identification and passwords, users are classified as either Operators or Administrators. Operators are restricted to media creation functions, while Administrators can also access configuration items. Regardless of user classification, the CD *Power*PACS software provides an intuitive Graphical User Interface (GUI) designed to speed the media creation and customization process.

B. *Startup Screen & Login Window*

The Startup Screen & Login Window appear when the CD *Power*PACS application successfully launches. The associated displays comprise two sections:

?? Startup Screen.
?? Login Window.

The **Startup Screen**, as illustrated in Figure 4-1, provides administrative information, such as logo, software name, revision level, trademark, and copyright information. The CD *Power*PACS software performs several background tasks while this window is open.

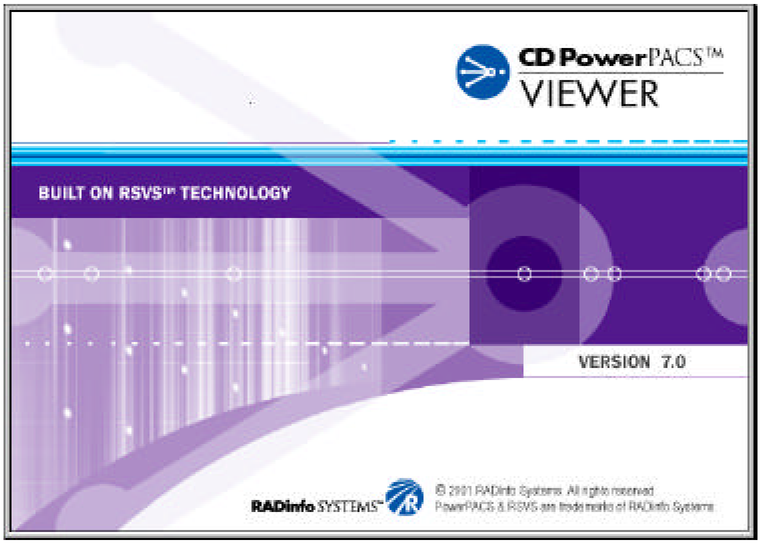

CD PowerPACS™
VIEWER
BUILT ON RSVS™ TECHNOLOGY
VERSION 7.0
RADinfo SYSTEMS™
© 2001 RADinfo Systems. All rights reserved.
PowerPACS & RSVS are trademarks of RADinfo Systems

Figure 4-1 Startup Screen

After a few seconds, these tasks are complete and the **Login Window** opens. The Login Window, as illustrated in Figure 4-2, controls access to GUI working levels.

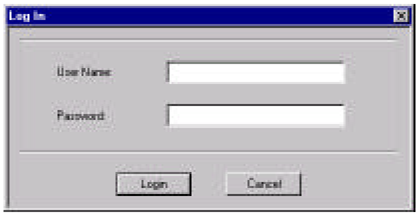


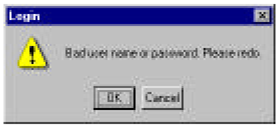
Figure 4-2 Login Window

The operator must correctly enter a valid **User Name** and **Password** before the program permits access to patient data or to the network. The user types a *Case Sensitive* Login ID (User Name) and Password in the appropriate boxes. The Login ID appears as clear text. For security reasons the password appears as a series of asterisks. In addition, the CD *Power*PACS automatically performs security checks to validate and verify network connectivity prior to exiting this window and displaying CD *Power*PACS Main Screen. Left-clicking the **OK** Button initiates the security validation process. Left-clicking the **Cancel** Button clears the fields without performing security validation.

Caution

The factory defaults for the Login ID and Password should be deleted and replaced with more secure combinations immediately following installation.

If the entries are not valid, an error message appears, as illustrated in Figure 4-3. Left-clicking the **OK** box returns the user to the Login Window. The application terminates after three unsuccessful attempts.



Bad user name or password. Please redo.

Figure 4-3 Login Error

If the Login ID and Password are valid, the CD *Power*PACS attempts to connect with the designated DICOM network devices.

C. CD PowerPACS GUI

Refer to Figure 4-4 for a representation of the CD *Power*PACS Main Screen GUI. The CD *Power*PACS features a Graphical User Interface (GUI) with a hierarchical screen arrangement. The GUI allows operators to use the mouse and keyboard to efficiently move through the GUI and to select, enter, and manage data. The primary GUI screen contains four areas of significance:

?? TOP MENU BAR: Four pull-down menus, at the upper left of the window.
?? DISK SPACE ICON: Oval icon, at the upper right of the window.
?? WORKING WINDOWS: Four sub-windows comprising the majority of the window.
?? FUNCTION BUTTONS: Six Function Buttons, across the lower section of the window.

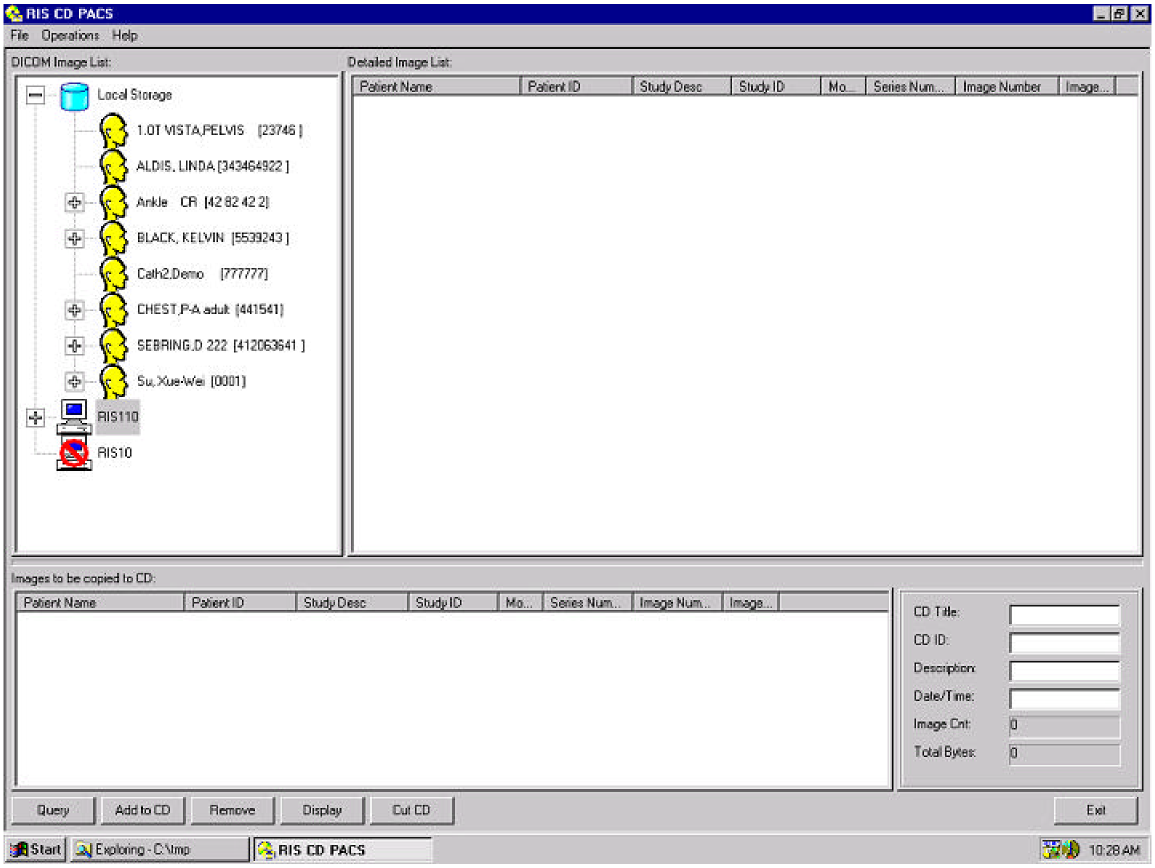

RIS CD PACS
File
Operations
Help
DICOM Image List:
Local Storage
1.0T VISTA,PELVIS [23746]
ALDIS, LINDA [343464922]
Ankle CR [42 82 42 2]
BLACK, KELVIN [5539243]
Cath2,Demo [777777]
CHEST,P-A adult [441541]
SEBRING,D 222 [412063641]
Su,Xue-Wei [0001]
RIS110
RIS10
Detailed Image List:
Patient Name
Patient ID
Study Desc
Study ID
Mo...
Series Num...
Image Number
Image...
Images to be copied to CD:
Patient Name
Patient ID
Study Desc
Study ID
Mo...
Series Num...
Image Num...
Image...
CD Title:
CD ID:
Description:
Date/Time:
Query
Add to CD
Remove
Display
Cut CD
Exit
Start
Exploring - C:\tmp
RIS CD PACS
10:28 AM

Image Cnt: 0
Total Bytes: 0

Figure 4-4 Main Screen GUI

Functionally, this hierarchical structure is represented in Figure 4-5. There are several obvious features associated with this structure. Most notably, many functions —**Query** and **Cut CD** for instance—are accessed through several different paths; this is a convenience for operators.

NOTE

There are slight functional and organizational differences between the Administrator and Operator GUIs. Administrators have additional features associated with the File Menu. These allow control of configuration and account security. These are dimmed when using an Operator account.

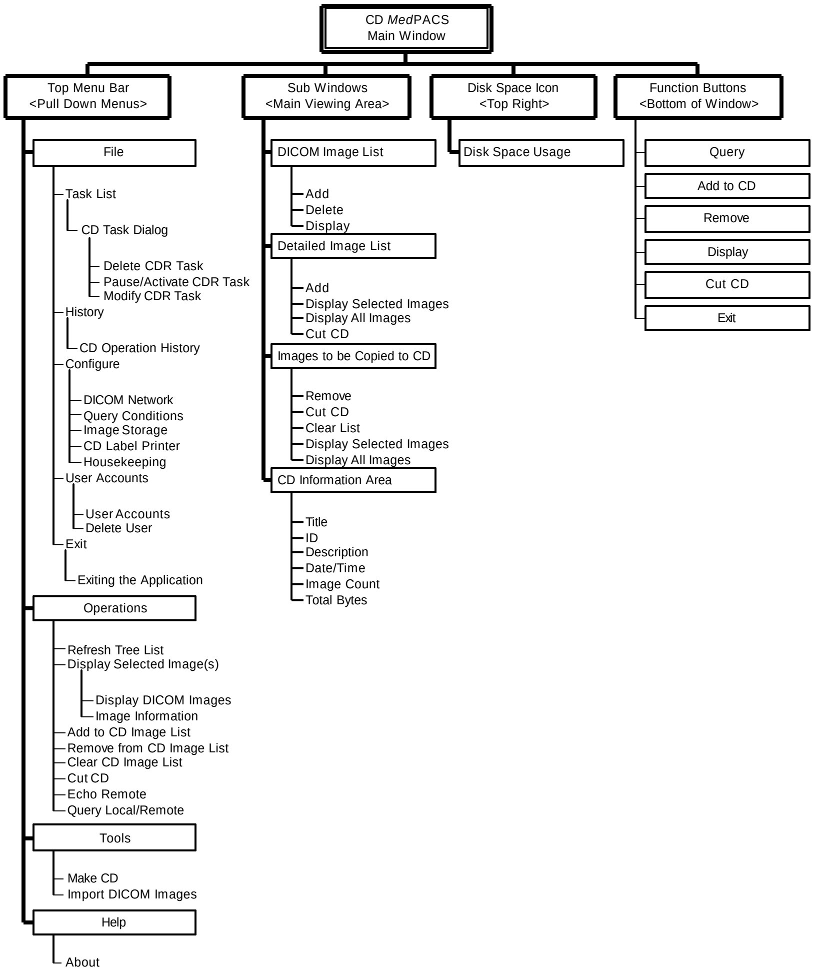

CD *Med*PACS
Main Window
Top Menu Bar
<Pull Down Menus>
Sub Windows
<Main Viewing Area>
Disk Space Icon
<Top Right>
Function Buttons
<Bottom of Window>
File
Task List
CD Task Dialog
Delete CDR Task
Pause/Activate CDR Task
Modify CDR Task
History
CD Operation History
Configure
DICOM Network
Query Conditions
Image Storage
CD Label Printer
Housekeeping
User Accounts
User Accounts
Delete User
Exit
Exiting the Application
Operations
Refresh Tree List
Display Selected Image(s)
Display DICOM Images
Image Information
Add to CD Image List
Remove from CD Image List
Clear CD Image List
Cut CD
Echo Remote
Query Local/Remote
Tools
Make CD
Import DICOM Images
Help
About
DICOM Image List
Add
Delete
Display
Detailed Image List
Add
Display Selected Images
Display All Images
Cut CD
Images to be Copied to CD
Remove
Cut CD
Clear List
Display Selected Images
Display All Images
CD Information Area
Title
ID
Description
Date/Time
Image Count
Total Bytes
Disk Space Usage
Query
Add to CD
Remove
Display
Cut CD
Exit

Figure 4-5 GUI Menu Structure

In addition, the CD *Power*PACS GUI provides several features common to the Windows Environment, as well as features typical for Windows database applications.

1. Standard Windows Environmental Features

The upper-right of most windows contains three icons, as illustrated in Figure 4-6.

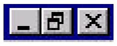


Figure 4-6 Standard Windows Navigational Icons

Left-clicking the icon to the left minimizes the window; the application remains active, but is hidden in the background. (Reopen the window by selecting its associated icon from the tray at the lower right of the screen.) Left-clicking the icon in the middle permits rapidly switching the window between two different sizes. Left-clicking the icon to the right (**X**) closes the active screen. When at the main screen, left-clicking this icon exits the program.

Rectangles containing text represent functions (executable commands). Refer to Figure 4-7. Left-clicking within a rectangle invokes the function/command. One rectangle has additional shadowing; indicating it is the selected command. Pressing the keyboard **Enter** key invokes this command. Using the keyboard **Tab** key moves the shadow box to change the selected command. The text and rectangle dim (gray) to indicate the function is not currently available for use.

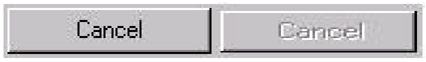


Figure 4-7 Function Buttons (Active and Not Active)

Small circles represent database sort/filter functions. Refer to Figure 4-8. Clicking within a circle invokes the associated sort/filter action. Only one filter is active at any given time.

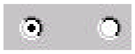


Figure 4-8 Sort/Filter Selections (Selected and Not Selected)

Checkboxes provide a convenient way to turn individual functions ON or OFF. Refer to Figure 4-9. A checkmark in a box indicates the function is ON. An empty box indicates the function is OFF.

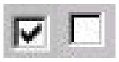


Figure 4-9 Checkboxes Selections (Selected and Not Selected)

As with most Windows applications, many commands have keyboard shortcuts. When this feature is available for a specific command, one letter of the command name is underlined. Holding down the **Alt** key and typing the underlined letter invokes the command.

2. Standard Windows Database Features

The upper portion of many areas contains database displays. The titles (headings) at the top of each column provide a fast way to sort the data or to resize the column. Left-clicking a heading title forces an ascending (a-z) sort; a second click forces a descending (z-a) sort. Subsequent clicks toggle between ascending and descending. A "hot spot" at the right of each heading permits resizing the column. When correctly positioned, the cursor changes to an "I" with thin, horizontal arrows. Left-clicking and dragging with this icon permits widening or narrowing the column.

Horizontal and vertical bars appear when the amount of data exceeds the capacity of the display window. Left-clicking the arrows permits scrolling up, down, right, or left, depending on the arrow selected. Left-clicking and moving the sliding bars permits rapid motion through the data.

Left-clicking a row selects and highlights that study. Holding the keyboard **Shift** key then left-clicking on the starting and ending rows permits selecting multiple *adjacent* studies. Holding the keyboard **Ctrl** (Control) key then left-clicking desired rows permits selecting multiple *non-adjacent* studies.

D. Top Menu Bar (Pull-Down Menu Selections)

The CD *Power*PACS Main Screen Top Menu Bar provides three pull-down menu selections. These are located in the upper right of the screen. Refer to Figure 4-10. From left-to-right, these are:

?? File.
?? Operations.
?? Tools.
?? Help.

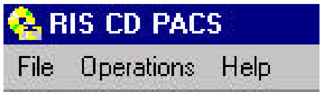

RIS CD PACS
File
Operations
Help

Figure 4-10 Pull Down Menu Selections

Moving the cursor above a selection and left -clicking opens an associated menu, as described in the following sections.

1. File

The File Pull Down Menu provid es a convenient method to access six general commands associated with status of the CD *Power*PACS software. Refer to Figure 4-11.

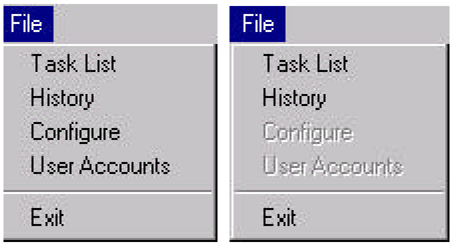

File
Task List
History
Configure
User Accounts
Exit
File
Task List
History
Configure
User Accounts
Exit

Figure 4-11 File Pull Down Menus

NOTE

> Refer to Figure 4-11. The appearance of the File menu changes with the login level of the user. Administrative users (left) have access to all five functions, including configuration items and user accounts. Operators (right) have access to only three of these items; they cannot access configuration items and user accounts.

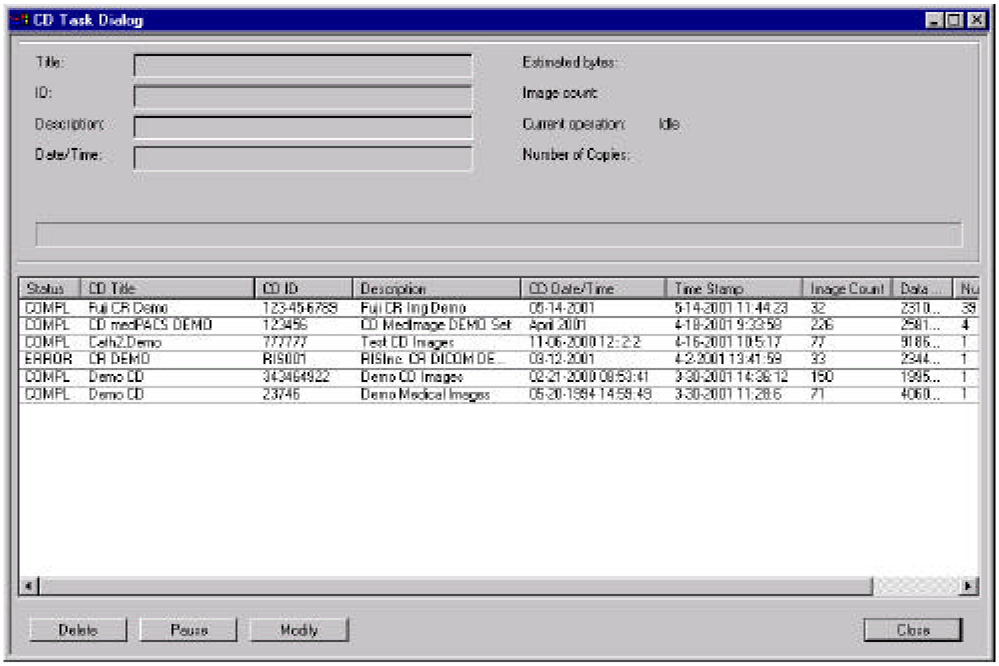
Each of the five general commands is explained in the following sections. Each command opens an associated window:

?? Task List.
?? History.
?? Configure.
?? User Accounts.
?? Exit.

a. Task List

Selecting the **Task List** Command invokes the **Task Dialog** Window. This window provides operators with task status and indication. Refer to Figure 4-12 and Figure 4-13. The **Task Dialog** Window comprises four main portions, as described in the following sections:

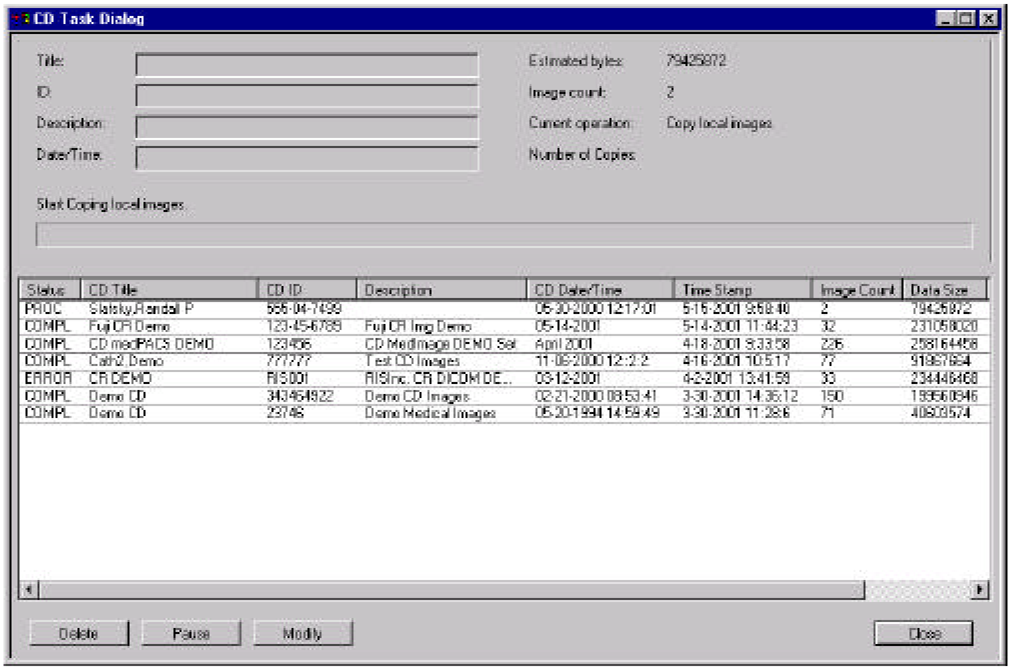
?? Text and Demographic Information.
?? Progress Bar.
?? List of Tasks.
?? Function Buttons.



Title:
ID:
Description:
Date/Time:
Estimated bytes:
Image count:
Current operation: Idle
Number of Copies:

Status	CD Title	CD ID	Description	CD Date/Time	Time Stamp	Image Count	Data ...	Nu
COMPL	Fuji CR Demo	123-45-6789	Fuji CR Img Demo	05-14-2001	5-14-2001 11:44:23	32	2310...	39
COMPL	CD medPACS DEMO	123456	CD MedImage DEMO Set	April 2001	4-18-2001 9:33:58	226	2581...	4
COMPL	Cath2.Demo	777777	Test CD Images	11-06-2000 12::2:2	4-16-2001 10:5:17	77	9186...	1
ERROR	CR DEMO	RIS001	RISInc. CR DICOM DE...	03-12-2001	4-2-2001 13:41:59	33	2344...	1
COMPL	Demo CD	343464922	Demo CD Images	02-21-2000 08:53:41	3-30-2001 14:36:12	150	1995...	1
COMPL	Demo CD	23746	Demo Medical Images	05-20-1994 14:59:49	3-30-2001 11:28:6	71	4060...	1

Figure 4-12 Task Dialog Window (Idle)



Title:
ID:
Description:
Date/Time:
Estimated bytes: 79425872
Image count: 2
Current operation: Copy local images
Number of Copies:

Start Coping local images

Status	CD Title	CD ID	Description	CD Date/Time	Time Stamp	Image Count	Data Size
PROC	Slatsky,Randall P	555-04-7499		05-30-2000 12:17:01	5-15-2001 9:58:40	2	79425872
COMPL	Fuji CR Demo	123-45-6789	Fuji CR Img Demo	05-14-2001	5-14-2001 11:44:23	32	231058020
COMPL	CD medPACS DEMO	123456	CD MedImage DEMO Set	April 2001	4-18-2001 9:33:58	226	258164458
COMPL	Cath2.Demo	777777	Test CD Images	11-06-2000 12::2:2	4-16-2001 10:5:17	77	91867664
ERROR	CR DEMO	RIS001	RISInc. CR DICOM DE...	03-12-2001	4-2-2001 13:41:59	33	234446468
COMPL	Demo CD	343464922	Demo CD Images	02-21-2000 08:53:41	3-30-2001 14:36:12	150	199560946
COMPL	Demo CD	23746	Demo Medical Images	05-20-1994 14:59:49	3-30-2001 11:28:6	71	40803574

Figure 4-13 CD Task Dialog Window (Copy In Process)

i. Text and Demographic Information

The upper portion of the **Task Dialog** Window displays text and numeric demographic information for selected images. Each item is described in the following bullets. Items are described from top-to-bottom, left-to-right.

?? **Title**—The media title (as it will appear on the silk-screen). *Unless altered, this is the name of the first patient selected in the storage set, as taken from the associated DICOM header.*

?? **ID**—Patient ID. Unless altered, this is the ID of the first patient selected in the storage set, as taken from the associated DICOM header.

?? **Description**—Alphanumeric description of the study. Unless altered, this is the description of the first study selected in the storage set, as taken from the associated DICOM header.

?? **Date/Time**—Creation date and time of the first study. Unless altered, this is the date and time of the first study selected in the storage set, as taken from the associated DICOM header.

?? **Estimated bytes**—Aggregate of bytes required (storage volume) all DICOM images selected in the storage set. The number in Figure 4-14 indicates 79,425,872 bytes, which roughly approximates 79 Mega Bytes (MB). A typical CD ROM media holds at least 650 MB.

?? **Image Count**—Aggregate of images selected in the storage set.

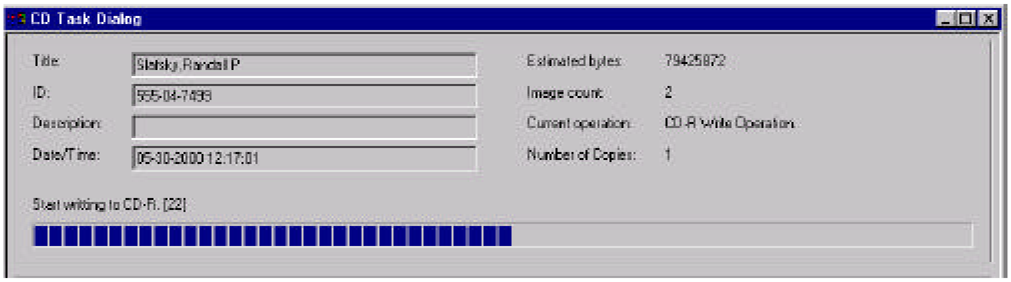
?? **Current Operation**—Simple description of the current task:

- o **Idle**—There are no current tasks; CD *Power*PACS is idle.
- o **Copy Local Images**—CD *Power*PACS software is moving images from the local hard drive to a designated storage location in preparation for media writing.
- o **Retrieve Remote Images**—CD *Power*PACS software is moving images from a remote, networked hard drive to a designated storage location in preparation for media writing.
- o **Cut CD-R**—CD *Power*PACS software acknowledges receipt of the create media command.
- o **Cutting CD-R**—CD *Power*PACS software begins the process of creating media.
- o **CD-R Write Operation**—The media-writing device is placing images on the selected media.

?? **Number of Copies**—Indicates the number of media specified to be written from this storage set.

ii. Progress Bar

A large, blue horizontal indicator provides visual status and indicates percent completion of tasks in progress. The bar begins at the left (0% progress) and expands to the right (100% Complete). Text immediately above the upper left of the bar indicates the current task. Refer to Figure 4-14.



Title: Slatsky,Randall P
ID: 555-04-7499
Description:
Date/Time: 05-30-2000 12:17:01
Estimated bytes: 79425872
Image count: 2
Current operation: CD-R Write Operation
Number of Copies: 1

Start writing to CD-R. [22]

Figure 4-14 CD Task Dialog Window (In Process Task)

iii. List of Tasks

The large, middle portion of **Task Dialog** Window provides a detailed list of tasks. Each task occupies a single row. Tasks are nominally organized according to task creation, with the most recent task at the top of the list. A sliding bar at the bottom of this portion permits repositioning the window to view all displayed data.

Headers at the top of each column identify information according to:

?? **Status**—Single-word description of task status.

- ?? **PROC** = (PROCESSING) Identifies tasks currently executing or waiting in the queue.
- ?? **COMPL** = (COMPLETED) Task completed without error.
- ?? **ERROR** = (ERROR) Task terminated before completion.

?? **CD Title**—The media title, as it will appear on the silk-screen. Unless altered, this is the name of the first patient selected in the storage set, as taken from the associated DICOM header.

?? **CD ID**—Patient ID. Unless altered, this is the ID of the first patient selected in the storage set, as taken from the associated DICOM header.

?? **Description**—Alphanumeric description of the study. Unless altered, this is the description of the first study selected in the storage set, as taken from the associated DICOM header.

?? **CD Date/Time**—Media creation date and time. This is taken from the real-time clock of the workstation.

?? **Time Stamp**—Creation date and time of the first study. Unless altered, this is the date and time of the first study selected in the storage set, as taken from the associated DICOM header.

?? **Image Count**—Aggregate of images selected in the storage set.

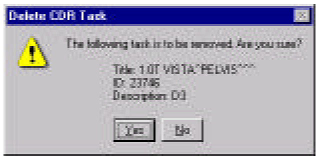
?? **Data Size**—Aggregate of bytes required (storage volume) all DICOM images selected in the storage set.

?? **Number of Copies**— Indicates the number of media specified to be written from this storage set.

iv. Function Buttons.

The lower portion **Task Dialog** Window provides four Function Buttons:

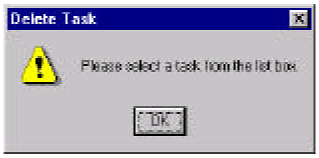
?? **Delete**—Invokes the **Delete CDR Task** Window. There are two general cases for this function. With tasks selected (highlighted), activating the function invokes the confirmation window illustrated in Figure 4-15. Selecting **Yes** deletes the task; Selecting **No** closes the window without deleting the task. In the event tasks were not selected, activating the function invokes the warning window illustrated in Figure 4-16. This window reminds operators to select a task for deletion. Selecting **OK** closes the window.



The following task is to be removed. Are you sure?

Title: 1.0T VISTA^PELVIS^^^
ID: 23746
Description: D3

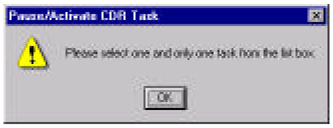
Figure 4-15 Delete CDR Task Window



Please select a task from the list box.

Figure 4-16 Delete Task Window

?? **Pause**—Suspends tasks in progress. The **Pause/Activate CDT Task** Window appears while the task is suspended. Selecting **OK** closes the window and resumes task processing. The **Pause** button automatically dims (not available) when no tasks are in progress.



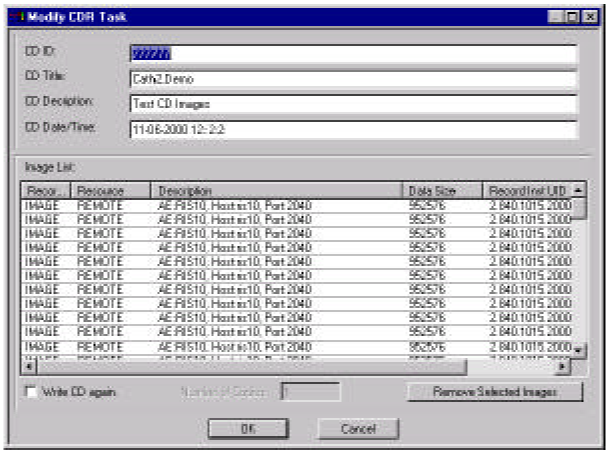
Please select one and only one task from the list box.

Figure 4-17 Pause/Activate CDR Task Window

CAUTION

The Pause function does not halt the media writing process. Attempts to halt the write process corrupt image data.

?? **Modify**—Invokes the **Modify CDR Task** Window, as illustrated in Figure 4-18. The four text entry fields at the top portion of the window permit manually changing tags associated with the selected task. Selecting any field (**CD ID**:, **CD Title**:, **CD Description**:, or **CD Date/Time:**) permits editing the default values taken from the DICOM header.



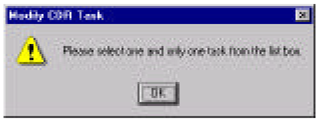
CD Title: Cath2 Demo
CD Description: Test CD Images
CD Date/Time: 11-06-2000 12:2:2

Figure 4-18 Modify CDR Task Window

The **Image List:** portion of the window displays selected images according to **Record Type** (Study, Series, or Image), **Resource** (Local or Remote), **Description** (Source DICOM workstation), **Data Size** (Byte count), and **Record Inst UID** (Unique Identification Number assigned according to established standards). Two sliders (horizontal and vertical) permit sliding the display window when data field size exceeds display capacity.

The **Write a CD again**. Checkbox at the lower left permits creating duplicate CDs from a single data source. The **Number of Copies box** displays the total media count specified for creation. The **Remove Selected Images** Button at the lower-right permits removing selected images from the task. Selecting **OK** enters any modifications and closes the window. Selecting **Cancel** closes the window without implementing modifications.

In the event tasks were not selected for modification, activating the function invokes the warning window illustrated in Figure 4-19. This window reminds operators to select at least one task for modification. Selecting **OK** closes the window.



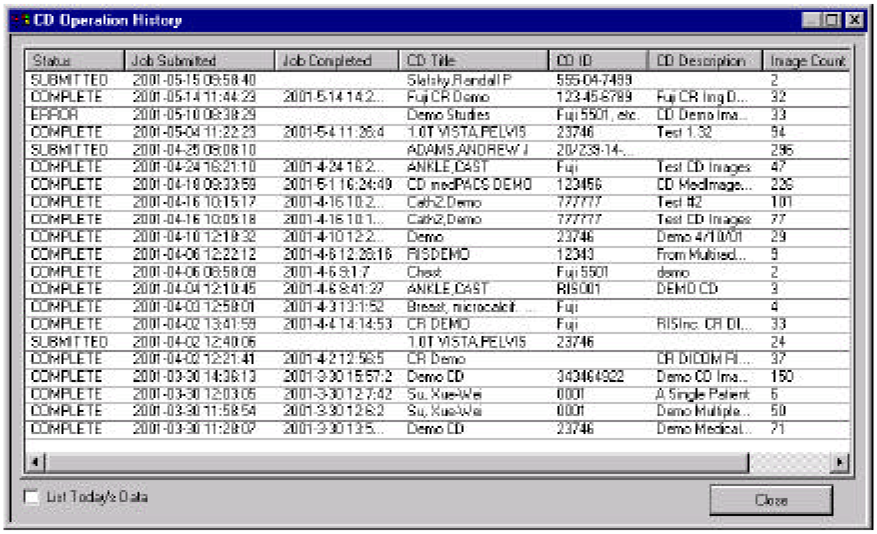
Please select one and only one task from the list box.

Figure 4-19 Modify CDR Task Warning

?? **Close**—Closes this window without canceling tasks in progress.

b. History

Selecting the **History** Command invokes the **CD Operation History** Window, as illustrated in Figure 4-20.



Status	Job Submitted	Job Completed	CD Title	CD ID	CD Description	Image Count
SUBMITTED	2001-05-15 09:58:40		Slatsky,Randall P	555-04-7499		2
COMPLETE	2001-05-14 11:44:23	2001-5-14 14:2...	Fuji CR Demo	123-45-6789	Fuji CR Img D...	32
ERROR	2001-05-10 09:38:29		Demo Studies	Fuji 5501, etc.	CD Demo Ima...	33
COMPLETE	2001-05-04 11:22:23	2001-5-4 11:26:4	1.0T VISTA,PELVIS	23746	Test 1.32	94
SUBMITTED	2001-04-25 09:08:10		ADAMS,ANDREW J	20/239-14-...		296
COMPLETE	2001-04-24 16:21:10	2001-4-24 16:2...	ANKLE,CAST	Fuji	Test CD Images	47
COMPLETE	2001-04-18 09:33:59	2001-5-1 16:24:49	CD medPACS DEMO	123456	CD MedImage...	226
COMPLETE	2001-04-16 10:15:17	2001-4-16 10:2...	Cath2,Demo	777777	Test #2	101
COMPLETE	2001-04-16 10:05:18	2001-4-16 10:1...	Cath2,Demo	777777	Test CD Images	77
COMPLETE	2001-04-10 12:18:32	2001-4-10 12:2...	Demo	23746	Demo 4/10/01	29
COMPLETE	2001-04-06 12:22:12	2001-4-6 12:28:16	RISDEMO	12343	From Multired...	9
COMPLETE	2001-04-06 08:58:09	2001-4-6 9:1:7	Chest	Fuji 5501	demo	2
COMPLETE	2001-04-04 12:10:45	2001-4-6 8:41:27	ANKLE,CAST	RIS001	DEMO CD	3
COMPLETE	2001-04-03 12:58:01	2001-4-3 13:1:52	Breast, microcalcif...	Fuji		4
COMPLETE	2001-04-02 13:41:59	2001-4-4 14:14:53	CR DEMO	Fuji	RISInc. CR DI...	33
SUBMITTED	2001-04-02 12:40:06		1.0T VISTA,PELVIS	23746		24
COMPLETE	2001-04-02 12:21:41	2001-4-2 12:56:5	CR Demo		CR DICOM FI...	37
COMPLETE	2001-03-30 14:36:13	2001-3-30 15:57:2	Demo CD	343464922	Demo CD Ima...	150
COMPLETE	2001-03-30 12:03:05	2001-3-30 12:7:42	Su, Xue-Wei	0001	A Single Patient	6
COMPLETE	2001-03-30 11:58:54	2001-3-30 12:6:2	Su, Xue-Wei	0001	Demo Multiple...	50
COMPLETE	2001-03-30 11:28:07	2001-3-30 13:5...	Demo CD	23746	Demo Medical...	71

☐ List Today's Data

Figure 4-20 Operation History Window

The **Operation History** Window provides users with detailed listing of media writing tasks, including the following status and information fields:

- **Status**— Single-word description of task status.
  - **SUBMITTED** = Identifies tasks currently waiting in the queue. Specifically, the task has been prepared by CD *Power*PACS, forwarded to the media-writing device, and awaiting processing by the media-writing device.
  - **COMPLETE** = Task completed without error. The media-writing device completed the writing task and created media containing all selected images, without error.
  - **ERROR** = Task abnormally terminated before completion.
- **Job Submitted**—Date and time the task was sent to the media writer. The date is in the format of Year, Month, Day (YYYY-MM-DD). The time is in the format of Hour, Minute, Second (HH-MM-SS). Time is based on a 24-hour clock.
- **Job Completed**—Date and time the media writer returned a JOB COMPLETED message. The date is in the format of Year, Month, Day (YYYY-MM-DD). The time is in the format of Hour, Minute, Second (HH-MM-SS). Time is based on a 24-hour clock.
- **CD Title**—Alphanumeric description of the study. Unless altered, this is the description of the first study selected in the storage set, as taken from the associated DICOM header.
- **CD ID**—Patient ID. Unless altered, this is the ID of the first patient selected in the storage set, as taken from the associated DICOM header.
- **CD Description**—Alphanumeric description of the study. Unless altered, this is the description of the first study selected in the storage set, as taken from the associated DICOM header.
- **Image Count**—Aggregate of images selected in the storage set.
- **Data Size**—Aggregate of bytes required (storage volume) all DICOM images selected in the storage set.

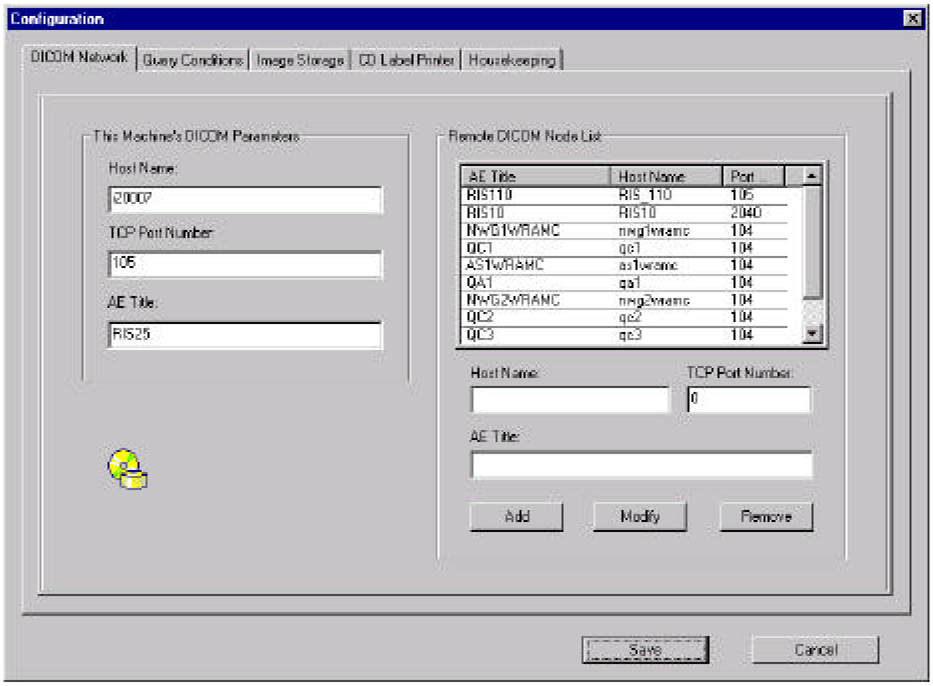
Selecting the **List Today's Data** checkbox in the lower left corner, filters the responses and removes all jobs with dates other than today's date. Selecting the **Close** Button closes the window.

c. Configure

Selecting the **Configure** Command invokes the **Configuration** Window, as illustrated in Figure 4-21. The top of the **Configuration** Window contains five tabs. Each tab invokes a different sheet in the main portion of the window. Two Function Buttons (**Save** and **Cancel**) at the lower right portion of the window permit users to enter configuration changes (**Save**) or to exit without saving changes (**Cancel**).

NOTE

The **Configuration** Window is only available to Administrative users.



This Machine's DICOM Parameters

Host Name: 20007

TCP Port Number: 105

AE Title: RIS25

Remote DICOM Node List

AE Title	Host Name	Port
RIS110	RIS_110	105
RIS10	RIS10	2040
NWG1WRANC	nwg1wranc	104
QC1	qc1	104
AS1WRANC	as1wranc	104
QA1	qa1	104
NWG2WRANC	nwg2wranc	104
QC2	qc2	104
QC3	qc3	104

Host Name:

TCP Port Number: 0

AE Title:

Figure 4-21 Configuration—DICOM Network

The functions provided by each of the four tabs are:

?? DICOM Network.
?? Query Conditions.
?? Image Storage.
?? CD Label Printer.
?? Housekeeping.

i. DICOM Network

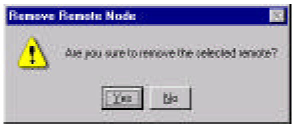
The **DICOM Network** Tab, as illustrated in Figure 4-21, permits setting critical values necessary to establish DICOM communications. Two function buttons at the bottom of the window control exit functions. The **Save** Button writes the selections into memory. The **Cancel** Button closes the window without altering existing values.

NOTE

The configuration boxes require keyboard entry of DICOM routing data necessary to properly identify network components. These four boxes contain literal configuration fields; the information entered must exactly match (case and space sensitive) the information entered at the corresponding device.

All DICOM communications require, at a minimum, identifying workstations by **Host Name**, **TCP Port Number**, and **AE Title**. The three entry boxes in the **This Machine's DICOM Parameters** section must be filled with the specific information for the CD *Power*PACS Workstation. The **Remote DICOM Node List** section permits entering similar information for workstations with which the CD *Power*PACS will communicate.

The three Function Buttons at the lower right of this section (**Add**, **Modify**, **Remove**) permit editing the DICOM Node list. When attempting to remove a DICOM Node, the **Remove Remote Node** warning of Figure 4-22 appears prior to removing the DICOM Node. Selecting **Yes** removes the node from the list. Selecting **No** closes the window and retains the node.

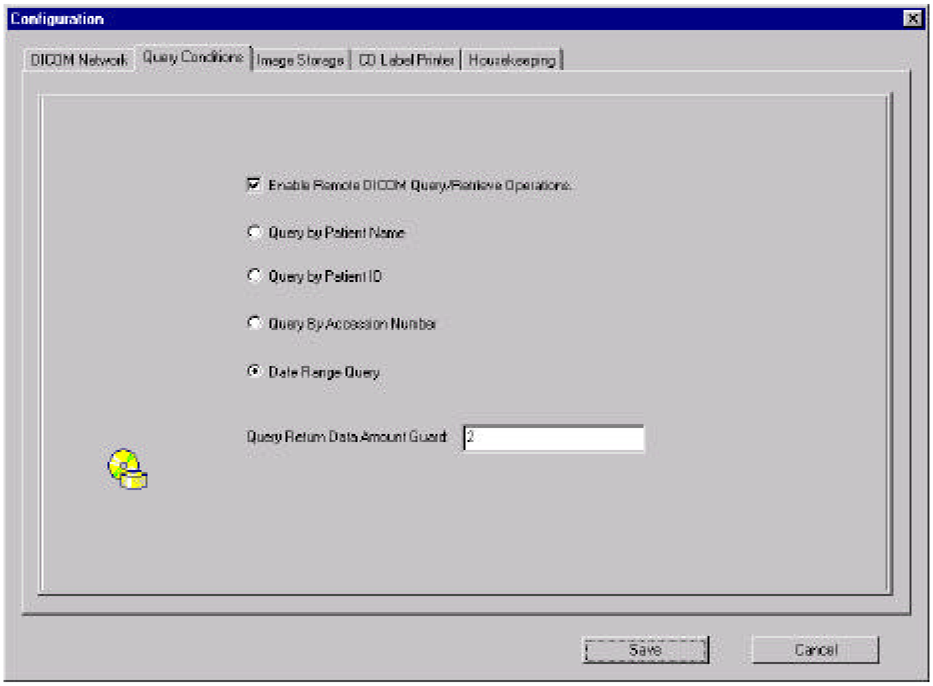


Are you sure to remove the selected remote?

Figure 4-22 Remove Remote Node Window

ii. Query Conditions

The **Query Conditions** Tab, as illustrated in Figure 4-23, permits setting default values for the **Query** Window. Two function buttons at the bottom of the window control exit functions. The **Save** Button writes the selections into memory. The **Cancel** Button closes the window without altering existing values.



☑ Enable Remote DICOM Query/Retrieve Operations

○ Query by Patient Name

○ Query by Patient ID

○ Query By Accession Numbe

● Date Range Query

Query Return Data Amount Guard: 2

Figure 4-23 Configuration—Query Conditions

An **Enable Remote DICOM Query/Retrieve Operations** checkbox at the top of the window enables DICOM responses from the CD *Power*PACS Workstation in response to DICOM query operations submitted to the CD *Power*PACS Workstation from authorized networked devices. Four selection buttons in the middle of the window (**Query by Patient Name**, **Query by Patient ID**, **Query by Accession Number**, and **Date Range Query**) allow administrators to specify the default query (search) field when the Query window first opens.

A **Query Return Data Amount Guard** field limits the number of hits sent by a remote device in response to a given query. The field accepts numbers in the range of 1 through 1,000 (inclusive). This is especially useful when submitting unrestricted query criteria; consider the number of entries that might be returned when seeking all Patient IDs beginning with the number “1” or when seeking all Patient Names beginning with the letter “S”.

NOTE

The **Query Return Data Amount Guard** determines when the **A large amount of records are received!** Window appears. Refer to Page 44, Chapter 4D.2.h.ii, Query Fields and Text Entry Box for more information.

iii. Image Storage

The **Image Storage** Tab, as illustrated in Figure 4-24, permits setting default storage locations used during media creation processes and set water marks used to prevent overflowing data storage capacity.

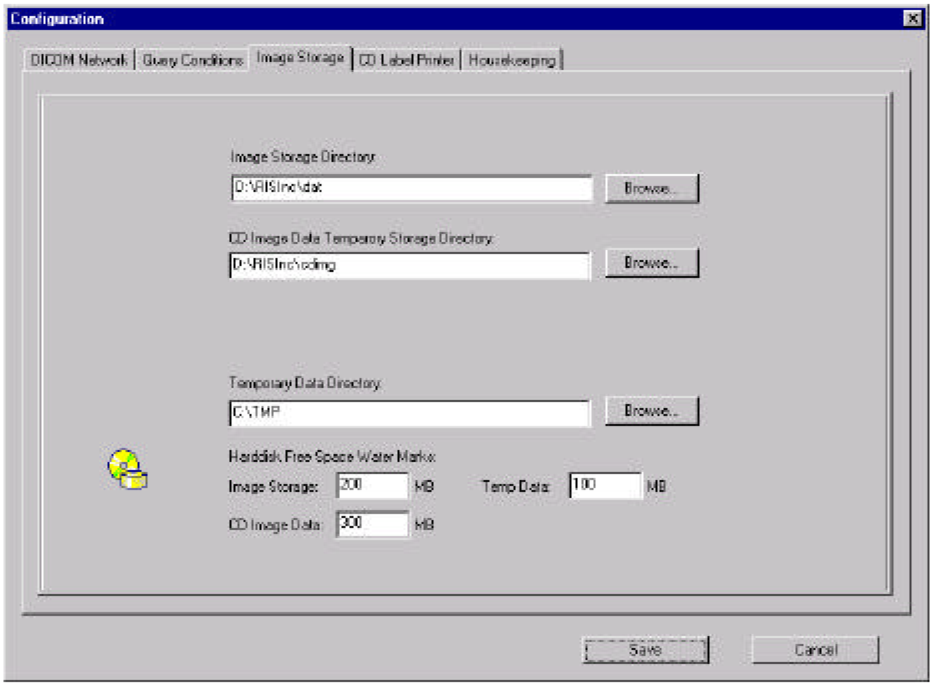


Image Storage Directory: D:\RISInc\dat

CD Image Data Temporary Storage Directory: D:\RISInc\cdimg

Temporary Data Directory: C:\TMP

Harddisk Free Space Water Marks:

Image Storage: 200 MB

Temp Data: 100 MB

CD Image Data: 300 MB

Figure 4-24 Configuration—Image Storage

The directory section comprises three text-entry fields and associated **Browse…** buttons. The **Image Storage Directory** permits specifying where images received from remote workstations are stored on the local volume. The **CD Image Date Temporary Storage Directory** permits specifying where storage sets are stored during the media creation process. The **Temporary Data Directory** permits specifying where transient data is stored by the CD *Power*PACS application. The **Browse…** Button, to the right of each text entry field, permits the use of standard windows navigational tools to specify these locations, as illustrated in Figure 4-25. Alternatively, file paths can be manually entered in the text field using standard Windows syntax.

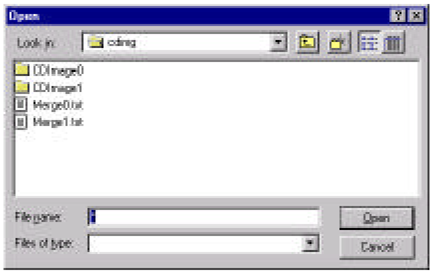

Open
Look in:
cdimg
CDImage0
CDImage1
Merge0.txt
Merge1.txt
File name:
Files of type:
Open
Cancel

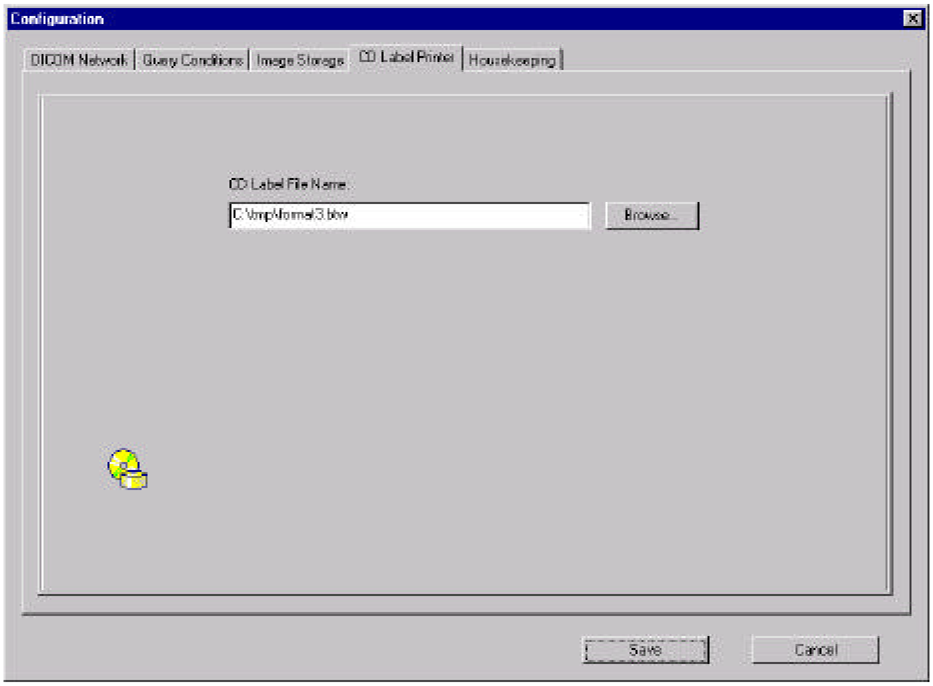
Figure 4-25 Image Storage Browse Button Dialog Window

The water mark section (**Harddisk Free Space Water Marks:**) comprises a set of three, numeric entry boxes. The CD *Power*PACS application halts image processing when the available free space of the folders specified in the directory section equals —or falls below—the number entered in its associated watermark box. This prevents image corruption or deletion due to insufficient volume (storage) space. Each water mark is independent of the others.

Two function buttons at the bottom of the window control exit functions. The **Save** Button writes the selections into memory. The **Cancel** Button closes the window without altering existing values.

iv. CD Label Printer

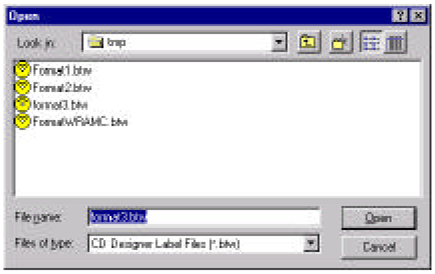
The **CD Label Printer** Tab, as illustrated in Figure 4-26, permits setting the default storage locations used to store templates used during the label printing process. Note that label files end with a **.btw** extension.


Configuration
DICOM Network
Query Conditions
Image Storage
CD Label Printer
Housekeeping
Browse...
Save
Cancel

CD Label File Name:
C:\tmp\format3.btw

Figure 4-26 CD Label Printer

The **CD Label File Name** permits specifying the storage location associated with media labels. The **Browse…** Button, to the right of the text entry field, permits the use of standard windows navigational tools to specify these locations, as illustrated in Figure 4-27. Alternatively, file paths can be manually entered in the text field using standard Windows syntax.


Open
Look in:
Open
Cancel

Look in: tmp

Format1.btw
Format2.btw
format3.btw
FormatWRAMC.btw

File name: format3.btw

Files of type: CD Designer Label Files (*.btw)

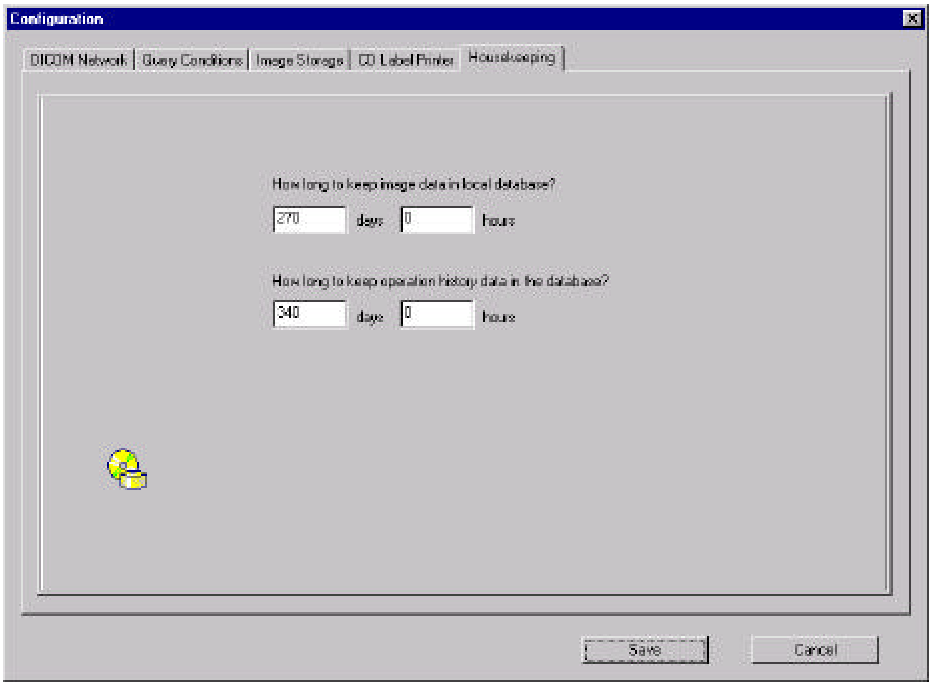
Figure 4-27 Browse CD Labels

v. Housekeeping

The **Housekeeping** Tab, as illustrated in Figure 4-28, permits specifying regular, periodic intervals for purging retained images from the CD *Power*PACS Workstation. Two function buttons at the bottom of the window control exit functions. The **Save** Button writes the selections into memory. The **Cancel** Button closes the window without altering existing values.

There are two numeric entry fields. These control the number of days and hours between automatic purges. The example given in Figure 4-28 indicates images are automatically purged every two (2) days.

Setting the **days** value to a negative number (i.e., -2) and activating the **Save** Button immediately purges all images.


Configuration
DICOM Network
Query Conditions
Image Storage
CD Label Printer
Housekeeping
Save
Cancel

How long to keep image data in local database?

270 days 0 hours

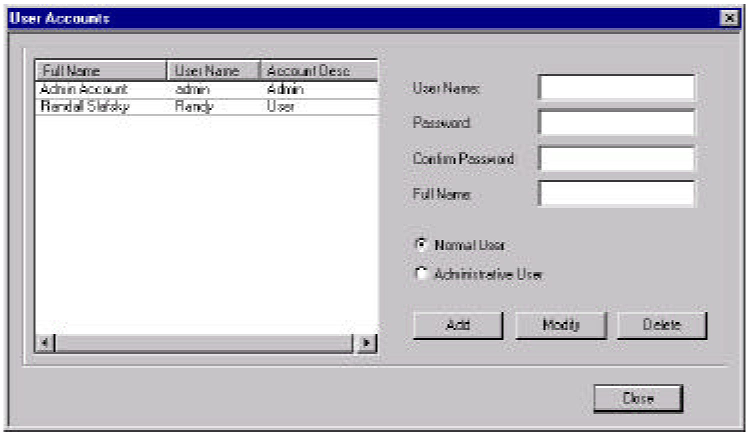
How long to keep operation history data in the database?

340 days 0 hours

Figure 4-28 Configuration—Housekeeping

d. User Accounts

Selecting the **User Accounts** Command invokes the **User Accounts** Window, as illustrated in Figure 4-29. This window permits managing password and login security functions.



Full Name	User Name	Account Desc
Admin Account	admin	Admin
Randall Slafsky	Randy	User

Figure 4-29 User Accounts

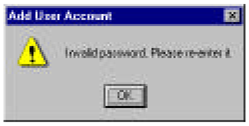
NOTE

The **User Accounts** Window is only available to Administrative users.

The **User Accounts** Window contains three sections:

?? List display (left side)—The List display provides visual indication all active accounts, including the **Full Name**, **User Name**, and **Account Description** for each user account. Clicking a row highlights that row and displays associated information in the data entry fields on the right.

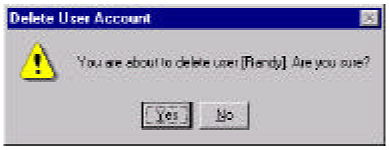
?? Data entry fields (right side)—The data entry fields permit entering alphanumeric information associated with each user account. The four entry fields (**User Name**, **Password**, **Confirm Password**, and **Full Name)** provide data entry for each field. The **Password** and **Confirm Password** fields must contain exact matches to prevent account rejection, as illustrated in Figure 4-30. The two selection buttons (**Normal User** and **Administrative User**) are mutually exclusive; accounts are classified as either Normal or Administrative.



Invalid password. Please re-enter it.

Figure 4-30 Add User Account Invalid Password

?? Function Buttons (bottom)—Four buttons at the bottom of the window control the **Add**, **Modify**, and **Delete** account features. Adding an account requires an exact match of characters entered into the **Password** and **Confirm Password** fields; clicking the **Add** button validates the entries and enters the changes into the List display. Modifying an account consists of selecting the row in the data base display and editing the text appearing in the data entry fields; clicking the **Modify** button enters the changes into the data base. Deleting an account consists of selecting the row in the data base display and clicking the Delete button; the warning illustrated in Figure 4-31 prevents inadvertent account deletion. Clicking **Yes** permanently removes the account. Clicking **No** retains the account and closes the window. The **Close** button permits users to exit.

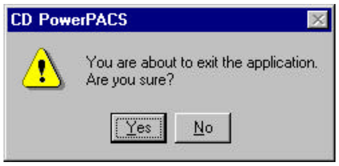

Delete User Account
Yes
No

You are about to delete user [Randy]. Are you sure?

Figure 4-31 Delete User Account Warning

e. Exit

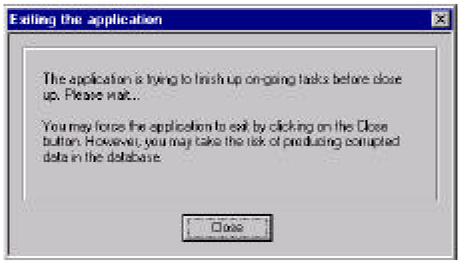
Selecting the **Exit** Command invokes the **RIS DICOM Image CD Creator** Window illustrated in Figure 4-32. Selecting **No** closes the window and returns control to the Main Window.


CD PowerPACS
Yes
No

You are about to exit the application.
Are you sure?

Figure 4-32 Exit Confirmation Window

Selecting **Yes** continues the exit process and invokes the dialog indicated in Figure 4-33. This window is a friendly reminder that background process must be completed to ensure images and storage sets are not corrupted. Selecting the **Close** Button terminates these processes at the risk of corruption.


Exiting the application
Close

The application is trying to finish up on-going tasks before close up. Please wait...

You may force the application to exit by clicking on the Close button. However, you may take the risk of producing corrupted data in the database.

Figure 4-33 Exiting the application…Dialog

2. Operations

The Operations Pull Down Menu provides a convenient method to access seven commands associated with image selection, media creation, and network operations. These commands are organized into four groups. Refer to Figure 4-34. The following paragraphs describe each command.

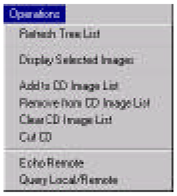

Operations
Refresh Tree List
Display Selected Images
Add to CD Image List
Remove from CD Image List
Clear CD Image List
Cut CD
Echo Remote
Query Local/Remote

Figure 4-34 Operations Pull Down Menu

a. Refresh Tree List

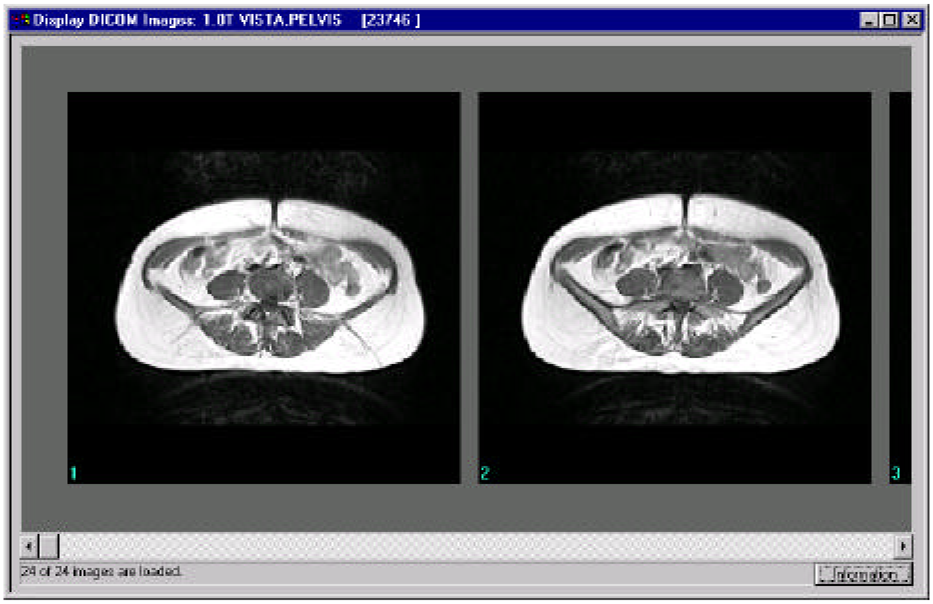
The **Refresh Tree List** Function works in conjunction with the **DICOM Image List** window. The **Refresh List** Command causes the CD *Power*PACS software to:

?? Revalidate DICOM connections to servers and workstations listed in the Node List.
?? Revalidate the image list of the local storage device.

The display will refresh with a current list after a slight delay.

b. Display Image(s)

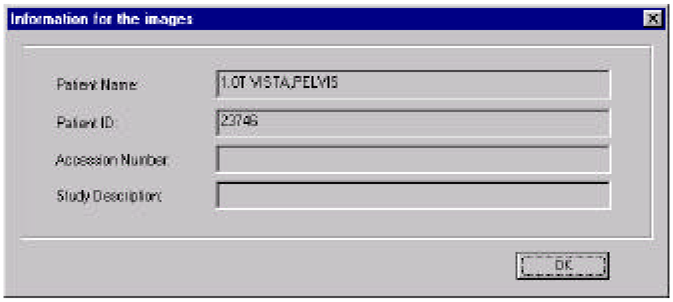
The **Display Image(s)** command permits viewing (previewing) selected DICOM images. Images selected may be indicated in the **DICOM Image List** window, the **Detailed Image List** window, or the **Images to be Copied to CD** window. Invoking this command opens the **Display DICOM Images** window illustrated in Figure 4-35.



24 of 24 images are loaded.

Figure 4-35 Display DICOM Images Window

The main portion of the window displays selected images. Images scroll from left -to-right, with image #1 at the far left. A message at the lower left (**24 of 24 images are loaded**) compares the number of images available for viewing with the number of images selected. Green numbers in the lower left corner of each image indicate the image number, as taken from the original DICOM header. Clicking an image selects and highlights that image. The lower right of the window contains an **Information** Button. Left-clicking this button opens the **Information for the images** window that displays demographic information associated with the selected image, as illustrated in Figure 4-36.


Information for the images

Patient Name: 1.0T VISTA,PELVIS

Patient ID: 23746

Accession Number:

Study Description:

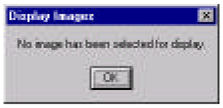
Figure 4-36 Image Information Window

The **Image Information** window provides four key pieces of information for the selected image:

?? Patient Name.
?? Patient ID.
?? Accession Number.
?? Study Description.

This information appearing in this window is taken from the DICOM header created by the imaging modality. Unless modified, the information contained in the **Patient Name** and **Patient ID** fields is written on the CD *PowerPACS Viewer* media label. Selecting the **OK** Button closes this window.

A warning appears in the event no images were selected before invoking the **Display Images** command, as illustrated in Figure 4-37.


Display Images

No image has been selected for display.

Figure 4-37 Display Images Warning

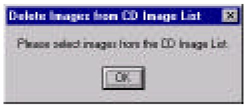
c. Add to CD Image List

The **Add to CD Image List** selection provides operators with a convenient method to move studies from the **DICOM Image List** Window to the **Detailed Image List** Window. The **Add** command inserts selected Studies, Series, and Images into the current storage set.

d. Remove from CD Image List

The **Remove from CD Image List** selection provides operators with a convenient method to remove *selected* studies from the **Images to be Copied to CD** Window. The **Remove** command deletes selected Studies, Series, and Images from the current storage set. Images selected for deletion must be indicated in the **Images to be Copied to CD** window.

Selecting this function when no images are highlighted in the **Images to be Copied to CD** Window opens the warning illustrated in Figure 4-38. Clicking **OK** closes the warning window.


Delete Images from CD Image List

Please select images from the CD Image List.

Figure 4-38 Delete Images CD Image List

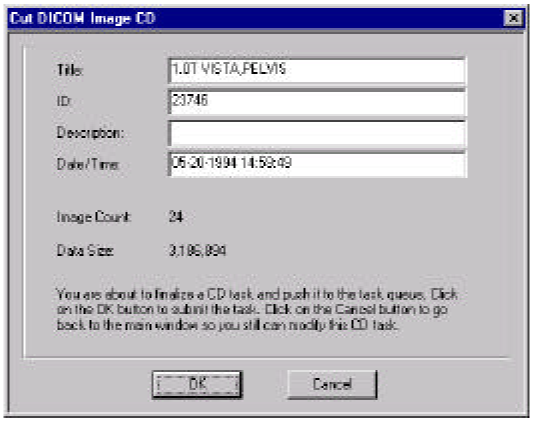
e. Clear CD Image List

The **Clear CD Image List** selection provides operators with a convenient method to remove *all* studies from the **Images to be Copied to CD** Window. The **Clear CD Image List** command removes all images from the current storage set. Once cleared, the storage set must be recreated; there is no "undo" function.

f. Cut CD

The **Cut CD** selection provides operators with a convenient method to begin writing storage sets to media. The storage set will consist of all images indicated in the **Images to be Copied to CD** Window and will be identified by information contained in the **CD Information Area** Window.

Invoking the **Cut CD** command begins the media creation process for the current storage set. Invoking this command opens the window illustrated in Figure 4-39. Two function buttons at the bottom of the window control exit functions. The **OK** Button begins the media creation process. The **Cancel** Button closes the window without creating a CD or altering existing storage sets.



Title: 1.0T VISTA,PELVIS
ID: 23746
Description:
Date/Time: 05-20-1994 14:59:49

Image Count: 24

Data Size: 3,186,894

You are about to finalize a CD task and push it to the task queue. Click on the OK button to submit the task. Click on the Cancel button to go back to the main window so you still can modify this CD task.

Figure 4-39 Cut DICOM Image CD

The top of the window contains four text-entry lines. These lines initially display information taken from the first image selected in the storage set, as taken from the DICOM header, as supplied by the imaging modality. These lines are:

?? **Title**—Unless altered, this is the patient name of the first study selected in the storage set, as taken from the associated DICOM header.

?? **ID**—Unless altered, this is the Patient ID of the first patient selected in the storage set, as taken from the associated DICOM header.

?? **Description**—Alphanumeric description of the study. Unless altered, this is the description of the first study selected in the storage set, as taken from the associated DICOM header.

?? **Date/Time**—The date and time of image creation *at the imaging modality*. The date follows a MM-DD-YYYY format. The Time follows a HH:MM:SS format, using a 24-hour clock.

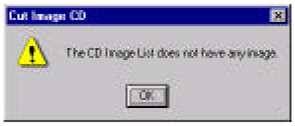
Text may be changed prior to beginning the media writing process. Whatever appears in these lines appears on the media label.

The middle portion of the window displays the number of images in the storage set (**Image Count**) and the aggregate size of all images contained in the storage set (**Data Size**), indicated in bytes.

NOTE

> CD *Power*PACS software does **not** permit creating storage sets whose data Size exceeds media capacity.

A warning appears in the event no images (Data Size = 0) were selected before invoking the **Cut CD** command, as illustrated in Figure 4-40.

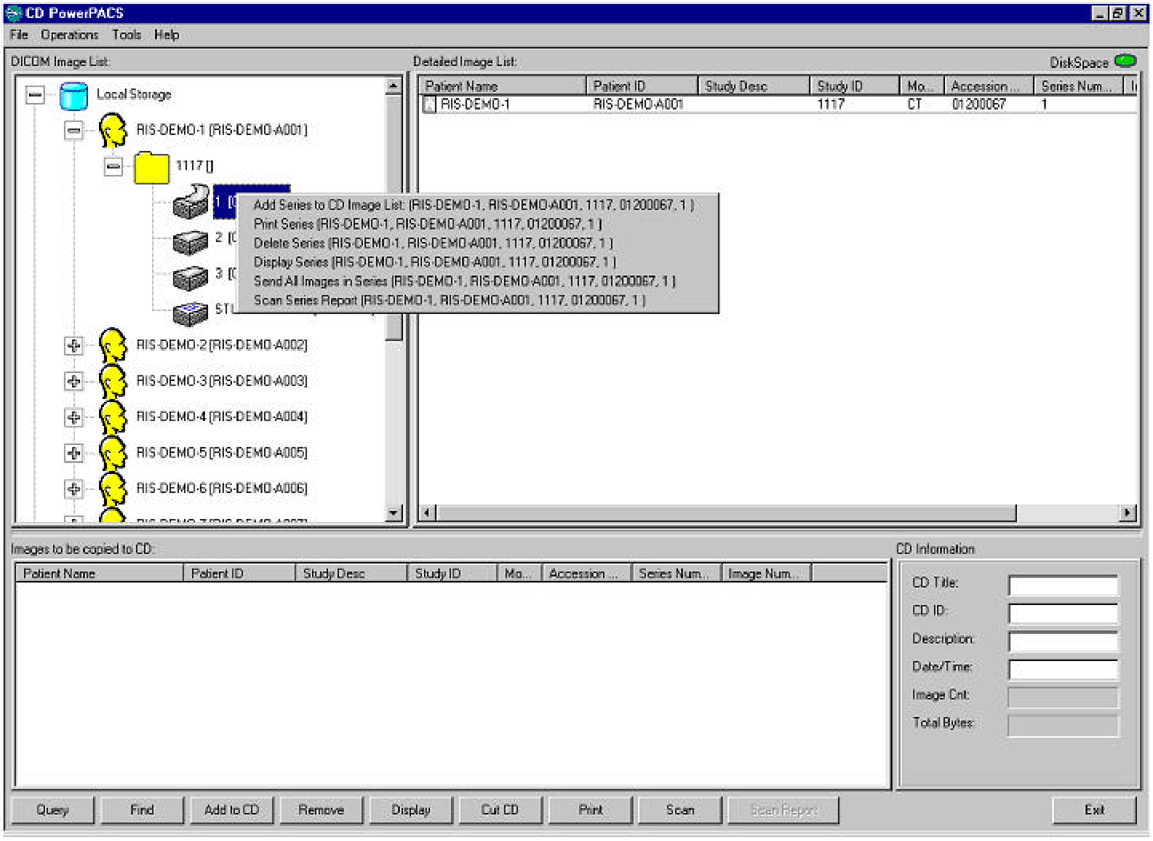

Cut Image CD
OK

The CD Image List does not have any image.

Figure 4-40 Cut Image CD Warning

Instructions written at the bottom of this window provide guidance for operators.

Figure 4-41 illustrates typical window layouts immediately prior to invoking the **Cut CD** command.

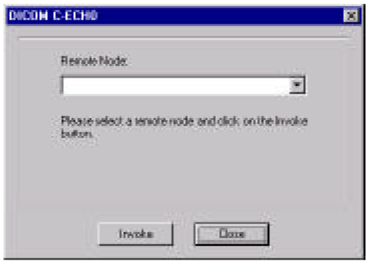

CD PowerPACS
File
Operations
Tools
Help
DICOM Image List:
Local Storage
RIS-DEMO-1 [RIS-DEMO-A001]
1117 []
1 [
2 [
3 [
STI
Add Series to CD Image List: [RIS-DEMO-1, RIS-DEMO-A001, 1117, 01200067, 1]
Print Series [RIS-DEMO-1, RIS-DEMO-A001, 1117, 01200067, 1]
Delete Series [RIS-DEMO-1, RIS-DEMO-A001, 1117, 01200067, 1]
Display Series [RIS-DEMO-1, RIS-DEMO-A001, 1117, 01200067, 1]
Send All Images in Series [RIS-DEMO-1, RIS-DEMO-A001, 1117, 01200067, 1]
Scan Series Report [RIS-DEMO-1, RIS-DEMO-A001, 1117, 01200067, 1]
RIS-DEMO-2 [RIS-DEMO-A002]
RIS-DEMO-3 [RIS-DEMO-A003]
RIS-DEMO-4 [RIS-DEMO-A004]
RIS-DEMO-5 [RIS-DEMO-A005]
RIS-DEMO-6 [RIS-DEMO-A006]
Detailed Image List:
DiskSpace
Images to be copied to CD:
Patient Name
Patient ID
Study Desc
Study ID
Mo...
Accession ...
Series Num...
Image Num...
CD Information
CD Title:
CD ID:
Description:
Date/Time:
Image Cnt:
Total Bytes:
Query
Find
Add to CD
Remove
Display
Cut CD
Print
Scan
Scan Report
Exit

Patient Name	Patient ID	Study Desc	Study ID	Mo...	Accession ...	Series Num...	I
RIS-DEMO-1	RIS-DEMO-A001		1117	CT	01200067	1	

Figure 4-41 Full Screen prior to CD Creation

g. Echo Remote

The **Echo Remote** command provides operators with a convenient method for validating DICOM communications between networked workstations. The **Echo Remote** command uses the DICOM C-ECHO function to validate these communications. Invoking the command opens the DICOM C -ECHO window, as illustrated in Figure 4-42.


DICOM C-ECHO
Remote Node:
Invoke
Close

Please select a remote node and click on the Invoke button.

Figure 4-42 DICOM C-ECHO

As with the **Query** function, the top portion (**Remote Node**) permits identifying the DICOM Workstation to be queried. To ensure patient confidentiality and to comply with contemporary security requirements, selections can only be made from a list of workstations previously entered and configured by authorized administrators. Clicking the arrow at the far right of the line displays a list of authorized workstations, as shown in Figure 4-43. (Recall that authorized workstations comprise only those workstations entered into the **DICOM Network Configuration** tab, illustrated in Figure 4-21.)

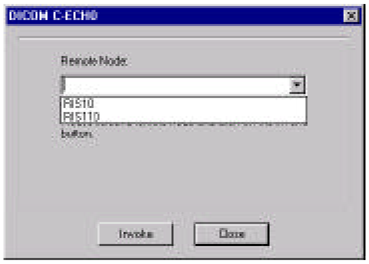
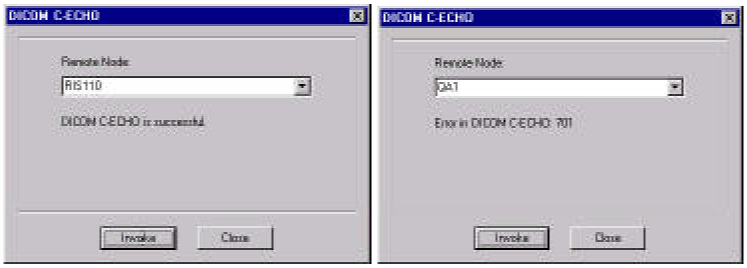

DICOM C-ECHO
Remote Node:
RIS10
RIS110
button.
Invoke
Close

Figure 4-43 DICOM C-ECHO Node Selection

The **Close** Button closes the window without echoing the selected workstation. Selecting the **Invoke** Button begins the echo. Text in the middle of the window reflects status of the echo. Figure 4-44indicates a successful echo.


DICOM C-ECHO
Remote Node:
Invoke
Close
DICOM C-ECHO
Remote Node:
Invoke
Close

RIS110

DICOM C-ECHO is successful

QA1

Error in DICOM C-ECHO: 701

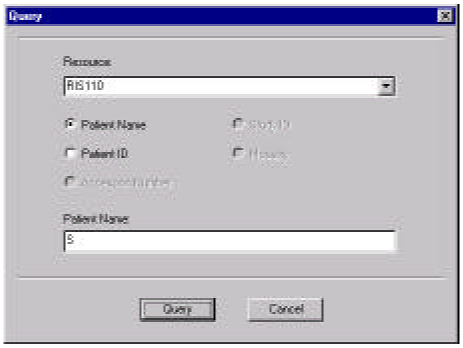
Figure 4-44 Echo Status Messages

CAUTION

> *Failure to obtain a successful C-ECHO indicates DICOM communications cannot be established with the selected remote node. This indicates the need for additional investigation. It does* ***not*** *indicate an inoperable workstation or a down network.*

h. Query Local/Remote

Selecting **Query Local/Remote** opens the Query Window. This window facilitates manual initiation of a DICOM Query command, which permits interrogating DICOM workstations with specific, focused requests. Refer to Figure 4-45.



Query

Resource: RIS110

● Patient Name

○ Patient ID

Patient Name: S

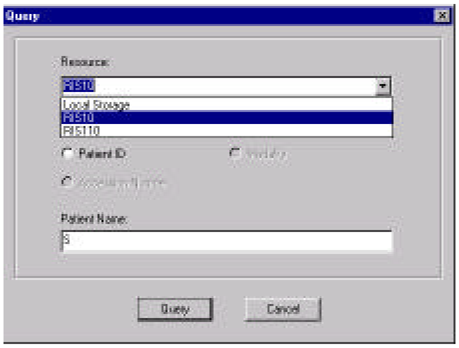
Figure 4-45 Query Window

The Query Window contains three sections.

?? Resource.
?? Query Fields and Text Entry Box.
?? Function Buttons.

i. Resource

The top portion (**Resource**) permits identifying the DICOM Workstation to be queried. To ensure patient confidentiality and to comply with contemporary security requirements, selections can only be made from a list of workstations previously entered and configured by authorized administrators. Clicking the arrow at the far right of the line displays a list of authorized workstations, as shown in Figure 4-46. The **Local Storage** option permits searching mass storage devices attached to the CD *Power*PACS Workstation. Other items appearing in the list represent networked DICOM workstations.



Resource: RIS10

Patient Name: S

Figure 4-46 Query Resource Selection

NOTE

> The CD *Power*PACS software sends a DICOM Query to a single workstation; it does not permit sending simultaneous, multiple queries. This reduces the possibility of flooding the workstation with large number of positive responses.

ii. Query Fields and Text Entry Box

Unrestricted queries usually result in a large amount of returned data. Refer to Figure 4-46. Selection buttons—located in the middle of the window—permit narrowing query criteria to a single DICOM data field. The Text Entry Box permits entering specific alphanumeric query criteria used to narrow the search.

The five buttons in the center of the screen are mutually exclusive; only one at a time may be active. When selected, the button is filled. The active selection forces textual changes in the Text Entry Box heading (title) immediately below the selection buttons. The five available selections are:

?? Patient Name.
?? Patient ID.
?? Accession Number.
?? Study ID.
?? Modality.

After selecting a button, operators enter literal character strings into the Text Entry Box.

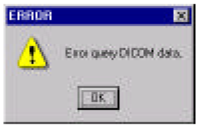
CAUTION

> *CD PowerPACS sends literal strings—exactly as entered—when performing queries. The receiving DICOM workstation interprets this information according to syntax rules established by the vendor. Therefore, use caution to ensure that the search string entered at the CD PowerPACS matches syntax constraints of the receiving workstation. Several vendors interpret query strings in the strictest literal sense. In these cases, entering standard wildcard characters (* or %) voids the search result.*

iii. Function Buttons

Two Function Buttons at the bottom of the window begin or end the query sequence. Selecting the **Query** Button begins the process. Selecting the **Cancel** Button aborts the process and closes the **Query** window.

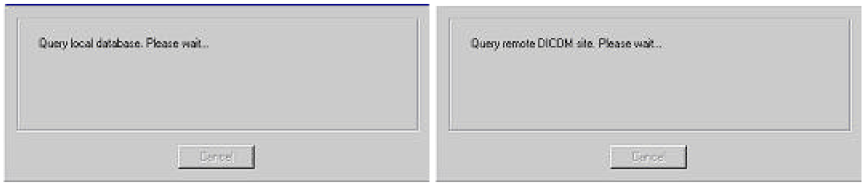
The CD *Power*PACS software does not permit null queries, and generates an error message in response to this condition. Refer to Figure 4-47. Selecting the **OK** Button closes this window.



Error query DICOM data.

Figure 4-47 Null Query Error Message

Various messages appear throughout the query process, as illustrated in Figure 4-48. The message at the left indicates the query involves the workstation’ s local hard drive; the network is not involved. The message at the right indicates the query transmits across the network to a remote DICOM workstation. Response times vary, but the local database query generally yields results much faster than a network query to a remote DICOM workstation. In the event the remote DICOM workstation fails to respond, a separate error message appears.

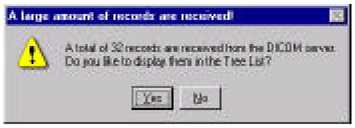


Query local database. Please wait...

Query remote DICOM site. Please wait...

Figure 4-48 Query in Process Message

Whenever excessive responses are received from remote DICOM workstations as a result of the query, a message window (**A large amount of records are receive d!**) appears indicating this condition. Refer to Figure 4-49. Under these circumstances, operators may optionally receive all responses or reject these and narrow the search. Selecting the **Yes** Button closes this window and displays query results. Selecting the **No** Button closes this window without displaying query results.



A total of 32 records are received from the DICOM server.
Do you like to display them in the Tree List?

Figure 4-49 Large Response Error Message

NOTE

Administrators determine and configure the number of responses deemed “excessive” using the **Query Conditions Configuration** Tab. Refer to Page 31, Chapter 4D.1.c.ii, Query Conditions for more information.

3. Tools

The **Tools** Pull Down Menu provides a convenient method to access two general commands associated with CD *Power*PACS software. Refer to Figure 4-50

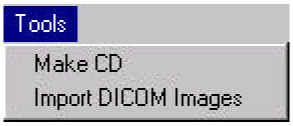


Figure 4-50 Tools Pull Down Menu

a. Make CD

The **Make CD** selection invokes the **Cut CD** function and opens the **Cut DICOM Image CD** Window previously illustrated as Figure 4-39. This was previously described on Page 39, Chapter 4D.2.f, Cut CD.

b. Import DICOM Images

The **Import DICOM Images** selection opens a dialog window used to facilitate importing DICOM images into the CD *Power*PACS application, as illustrated in Figure 4-51. This is especially useful when it is necessary to obtain DICOM images from removable media, such as CD/DVD ROM.

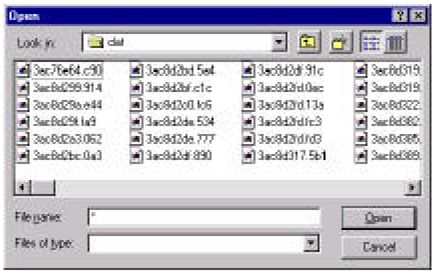


Figure 4-51 Import DICOM Images Window

4. Help

The Help Pull Down Menu provides access to a single screen. Refer to Figure 4-52.

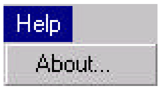
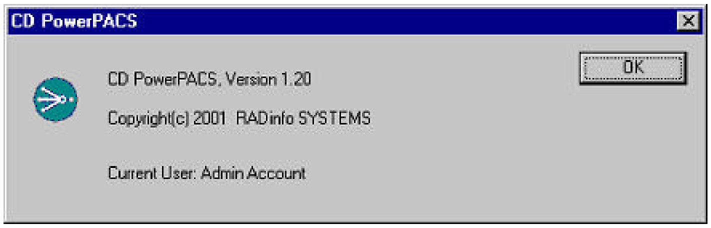


Figure 4-52 Help Pull Down Menu

Invoking the **About...** selection opens the **About RIS CD PowerPACS** Window, as illustrated in Figure 4-53. This window displays:

?? Version and copyright information.
?? Current User account identification.

Selecting the **OK** Button closes this window.



CD PowerPACS, Version 1.20

Copyright(c) 2001 RADinfo SYSTEMS

Current User: Admin Account

Figure 4-53 About RADinfo Systems CD *Power*PACS

E. Disk Space Icon

The **Disk Space Icon** appearing at the upper right of the Main Screen (as illustrated in Figure 4-54) provides visual indication of water mark status. A green icon indicates volume space is below all water marks. A red icon indicates at least one water mark is flooded.

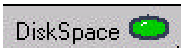
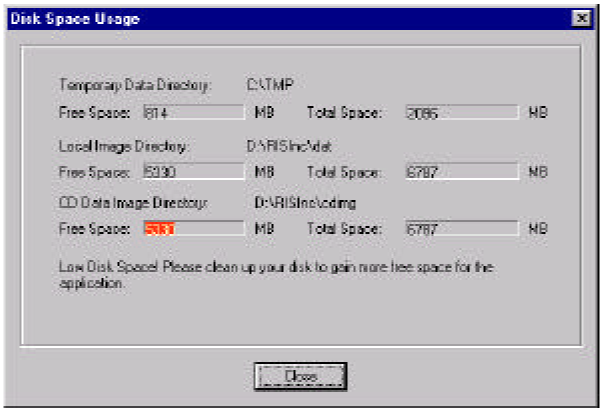


Figure 4-54 Disk Space Icon

NOTE

Refer to Page 32, Chapter 4D.1.c.iii, Image Storage, for configuration information and descriptions of water marks.

Double clicking the **Disk Space Icon** opens the **Disk Space Usage** window illustrated in Figure 4-55. This information window provides visual indication (orange-red background) to rapidly identify the problem area. Text and numeric data provide additional information necessary to isolate the problem.



Temporary Data Directory: C:\TMP

Free Space: 814 MB Total Space: 2085 MB

Local Image Directory: D:\RISInc\dat

Free Space: 5330 MB Total Space: 6787 MB

CD Data Image Directory: D:\RISInc\cdimg

Free Space: [illegible] MB Total Space: 6787 MB

Low Disk Space! Please clean up your disk to gain more free space for the application.

Figure 4-55 Disk Space Usage Window (Error Condition)

F. Sub Windows

As previously indicated, there are four Sub-Windows. Each performs separate and distinct tasks. However, certain shortcuts have been incorporated into each window to simplify the storage set creation process. Left-clicking an item selects it. Right-clicking an item invokes a pop-up menu.

The four Sub-Windows are:

?? DICOM Image List (Top Left).
?? Detailed Image List (Top Right).
?? Images to be Copied to CD (Bottom Left).
?? CD Information Area (Bottom Right).

1. DICOM Image List

The DICOM Image List sub-window occupies the upper left portion of the main screen, as shown on Page 21, in Figure 4-4 Main Screen GUI. The DICOM Image List is a multifunction sub window that:

?? Provides visual indication of connected device status.
?? Provides visual indication of available Studies, Series, and Images, organized by Patient Name.
?? Facilitates image selection for storage set creation.

a. Overview

Refer to Figure 4-56 (left, center, and right). The DICOM image list first appears as illustrated on the left side and evolves to the illustration on the right side as images are examined.

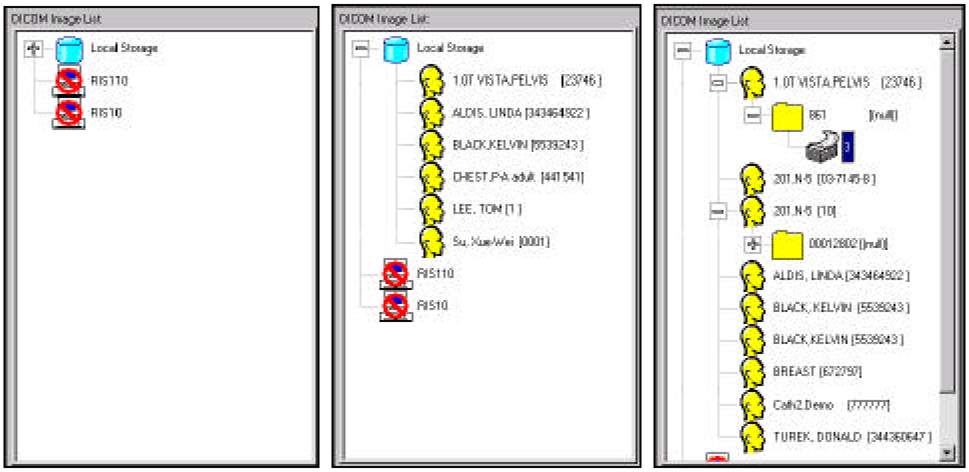

DICOM Image List
Local Storage
RIS110
RIS10
DICOM Image List
Local Storage
1.0T VISTA,PELVIS [23746]
ALDIS, LINDA [343464922]
BLACK,KELVIN [5539243]
CHEST,P-A adult [441541]
LEE, TOM [1]
Su, Xue-Wei [0001]
RIS110
RIS10
DICOM Image List
Local Storage
1.0T VISTA,PELVIS [23746]
861 [null]
3
201.N-5 [03-7145-B]
201.N-5 [10]
00012802 [null]
ALDIS, LINDA [343464922]
BLACK, KELVIN [5539243]
BLACK,KELVIN [5539243]
BREAST [672797]
Cath2.Demo [777777]
TUREK, DONALD [344360647]

Figure 4-56 DICOM Image List

An icon represents the **Local Storage** device. Terminal Device icons represent remote DICOM Workstations. Initially, **Local Storage** and all configured workstations (e.g. **RIS110** and **RIS10**) appear as icons. Dotted lines indicate hierarchical relationships within this structure. Icons with a + to their left indicate a lower level exists. Clicking the + opens this lower level; the + changes to a –. Clicking the – hides the level. The four hierarchical levels are organized by:

?? Storage Device.
?? Patient Names.
?? Patient Studies.
?? Patient Series & Images.

Configured workstations may initially appear with the universal "No" symbol. This indicates they are offline, or that information is not available for the workstation. Double clicking the workstation icon refreshes the connection and removes the "No" symbol. In the event this symbol does not clear, further investigation may be necessary. Table 4-1 identifies icons used in the DICOM Image List sub-window.

Table 4-1 DICOM Image List Icons

	Local Storage Device Icon
🖥	DICOM Workstation Icon (Online)
🖥	DICOM Workstation Icon (Offline)
⊞	Open And Examine Contents
⊟	Close And Hide Contents
	Image Copy Icon (Cursor Symbol)
	Image Selection Icon (Cursor Symbol)
	Patient Name Icon Selected (Contents are available for inspection in Detailed Image List)
	Patient Name Icon Deselected
📂	Patient Studies Icon Selected (Contents are available for inspection in Detailed Image List)
📁	Patient Studies Icon Deselected
	Patient Images Icon Selected (Contents are available for inspection in Detailed Image List)
	Patient Images Icon Deselected

Refer to Figure 4-56. The left view indicates three image sources are identified. The **Local Storage** device can be expanded, and both networked workstations are offline. The center view indicates the **Local Storage** device was opened and contains studies for six patients. The right view indicates three additional patients have been added to the **Local Storage** device. Records for two of these patients have been opened, as indicated by the folder icons (Patient Studies Icon Selected). Individual studies for one of these patients have been opened, as indicated by the stacked paper icon (Patient Images Icon Selected).

Each hierarchical level provides DICOM information, as indicated below:

?? Storage Device—Description of the device taken from data entered into the CD *Power*PACS configuration by administrators.
?? Patient Names—Line entries provide the **Patient Name** and **Patient ID**, as taken from DICOM headers.
?? Patient Studies— Line entries provide the **Study ID** and **Study Description**, as taken from DICOM headers.
?? Patient Series & Images—Line entries provide an exact **Image Count**, as taken from DICOM headers.

b. Operations

In addition to organizing and displaying Studies, Series, and Images, the **DICOM Image List** sub-window performs various tasks. These tasks involve image management functions and network management functions.

i. Image Management Functions

Image management tasks associated with the **DICOM Image List** sub-window include:

?? Sending Images to **Detailed Image List** sub-window.
?? Sending Images to **Images to be Copied to CD** sub-window.
?? Deleting Images.
?? Displaying Images.
?? Re-synchronizing data base.

Double-clicking a Study, Series, or Image sends that image to the **Detailed Image List** sub-window.

Selecting a Study, Series, or Image, then right-clicking the selection permits dragging the selection directly into the **Images to be Copied to CD** sub-window. The cursor changes to reflect the copy is in progress.

Right clicking over a specific Study, Series, or Image opens a popup menu similar to those illustrated in Figure 4-57. Text in the box changes to reflect the selection. In this illustration, the upper pop-up appears after selecting a Patient, while the lower appears after selecting a Series. In any event, information follows a defined syntax: **Patient Name**, **Patient ID**, **Study ID**, **Study Description**, and **Image Count**. Highlighting a line, then left clicking invokes the function identified on that line.

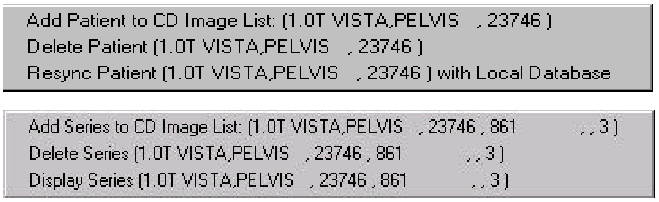

Add Patient to CD Image List: (1.0T VISTA,PELVIS , 23746)
Delete Patient (1.0T VISTA,PELVIS , 23746)
Resync Patient (1.0T VISTA,PELVIS , 23746) with Local Database
Add Series to CD Image List: (1.0T VISTA,PELVIS , 23746 , 861 , , 3)
Delete Series (1.0T VISTA,PELVIS , 23746 , 861 , , 3)
Display Series (1.0T VISTA,PELVIS , 23746 , 861 , , 3)

Figure 4-57 DICOM Image List—Image Management Popup Menu

The **Resync Patient (XXX) with Local Database** command provides a simple method to ensure additional patient Studies, Series, or Images have not been added since the last query. When invoked, the **Resync** command sends a query request to the associated DICOM workstation. The query search is limited to only the selected Patient. The results of the query are immediately compared with information contained in the Local Database, and the Local database is updated to reflect changes at the remote workstation.

ii. Network Management Functions

Network management tasks associated with the **DICOM Image List** sub-window include:

?? Invoking **C Echo**.
?? Invoking **Query**.

Double-clicking a device icon selects (highlights), then refreshes the image list associated with that device. Right clicking over a specific icon opens the popup menu illustrated in Figure 4-58. Highlighting the desired function and left clicking invokes the function.

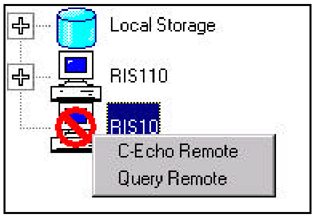
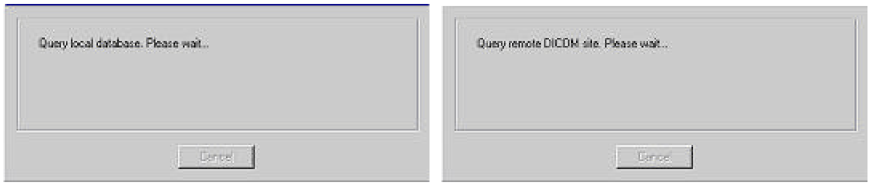

Local Storage
RIS110
RIS10
C-Echo Remote
Query Remote

Figure 4-58 DICOM Image List—Network Functions Popup Menu

When using the C-Echo function, pop-up menu text changes according to the type of device selected, as illustrated in Figure 4-59.


Query local database. Please wait...

Query remote DICOM site. Please wait...
Cancel
Cancel

Figure 4-59 Query Local/Remote Databases

As with the C-Echo function, pop-up menu text changes with the Query function. Figure 4-59 illustrates the menu accessed by selecting a remote device. Figure 4-60 illustrates the menu accessed by selecting the Local Storage device. The C-Echo command does not apply to the Local Storage Device.

Query Local Images

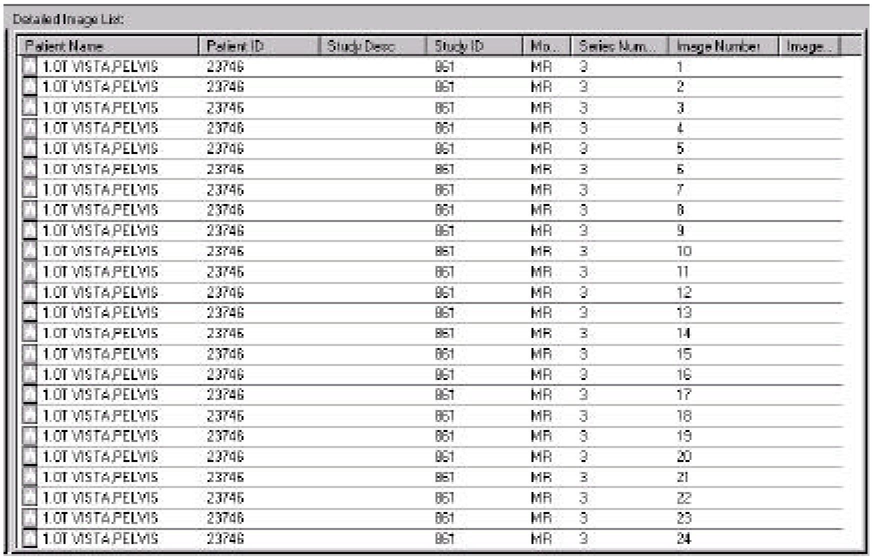
Figure 4-60 Query Popup

2. Detailed Image List

The Detailed Image List sub-window occupies the upper right portion of the main screen, as shown on Page 21, in Figure 4-4 Main Screen GUI. The Detailed Image List is a multifunction sub window that provides demographic information for selected images.

a. Overview

The **Detailed Image List** sub-window displays demographics information associated with image selections indicated in the **DICOM Image List** sub-window, as illustrated in Figure 4-61.



Patient Name	Patient ID	Study Desc	Study ID	Mo...	Series Num...	Image Number	Image...
1.0T VISTA,PELVIS	23746		861	MR	3	1	
1.0T VISTA,PELVIS	23746		861	MR	3	2	
1.0T VISTA,PELVIS	23746		861	MR	3	3	
1.0T VISTA,PELVIS	23746		861	MR	3	4	
1.0T VISTA,PELVIS	23746		861	MR	3	5	
1.0T VISTA,PELVIS	23746		861	MR	3	6	
1.0T VISTA,PELVIS	23746		861	MR	3	7	
1.0T VISTA,PELVIS	23746		861	MR	3	8	
1.0T VISTA,PELVIS	23746		861	MR	3	9	
1.0T VISTA,PELVIS	23746		861	MR	3	10	
1.0T VISTA,PELVIS	23746		861	MR	3	11	
1.0T VISTA,PELVIS	23746		861	MR	3	12	
1.0T VISTA,PELVIS	23746		861	MR	3	13	
1.0T VISTA,PELVIS	23746		861	MR	3	14	
1.0T VISTA,PELVIS	23746		861	MR	3	15	
1.0T VISTA,PELVIS	23746		861	MR	3	16	
1.0T VISTA,PELVIS	23746		861	MR	3	17	
1.0T VISTA,PELVIS	23746		861	MR	3	18	
1.0T VISTA,PELVIS	23746		861	MR	3	19	
1.0T VISTA,PELVIS	23746		861	MR	3	20	
1.0T VISTA,PELVIS	23746		861	MR	3	21	
1.0T VISTA,PELVIS	23746		861	MR	3	22	
1.0T VISTA,PELVIS	23746		861	MR	3	23	
1.0T VISTA,PELVIS	23746		861	MR	3	24	

Figure 4-61 Detailed Image List

The **Detailed Image List** sub-window displays the following demographic information, which is taken from the DICOM header of each image. Images are automatically sorted with the first image appearing at the top of the list. Information provided includes:

?? **Patient Name**—This is the Patient Name, as taken from the associated DICOM header.
?? **Patient ID**—This is the Patient ID, as taken from the associated DICOM header.
?? **Study Desc**(ription)—Alphanumeric description of the study. Unless altered, this is the description taken from the associated DICOM header.
?? **Study ID**—This is the ID of the first study, as taken from the associated DICOM header.
?? **Modality**—Two-letter abbreviation indicating the originating modality. Standard medical abbreviations apply (CT, MR, NM, US, etc.).
?? **Series Number**—The number of the series within the Patient Folder, as taken from the associated DICOM header.

?? **Image Number**— The number of the image within the Series, as taken from the associated DICOM header.

?? **Image Count**—Aggregate of images selected in the storage set.

b. Operations

The **Detailed Image List** sub-window performs various tasks in addition to displaying demographic information. Left clicking a specific line (row) selects that line. Right clicking then opens the popup menu illustrated in Figure 4-63. Highlighting the desired function and left clicking invokes the function.

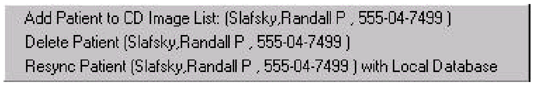

Add Patient to CD Image List: (Slafsky,Randall P , 555-04-7499)
Delete Patient (Slafsky,Randall P , 555-04-7499)
Resync Patient (Slafsky,Randall P , 555-04-7499) with Local Database

Figure 4-62 Detailed Image List Functions (Right Click)

After selecting the desired number of lines, left-clicking a selection opens the pop-up menu illustrated in Figure 4-63. These selections provide immediate access to the most useful functions associated with the **Detailed Image List** sub-window.

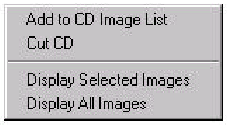

Add to CD Image List
Cut CD
Display Selected Images
Display All Images

Figure 4-63 Detailed Image List—Image Management Popup Menu

?? **Add to CD Image List**—Invokes the function previously described on Page 38, Chapter 4D.2.c, Add to CD Image List.

?? **Cut CD**—Invokes the function previously described on Page 39, Chapter 4D.2.f, Cut CD.

?? **Display Selected Images**—Invokes the function previously described on Page 37, Chapter 4D.2.b, Display Image(s), for the selected images.

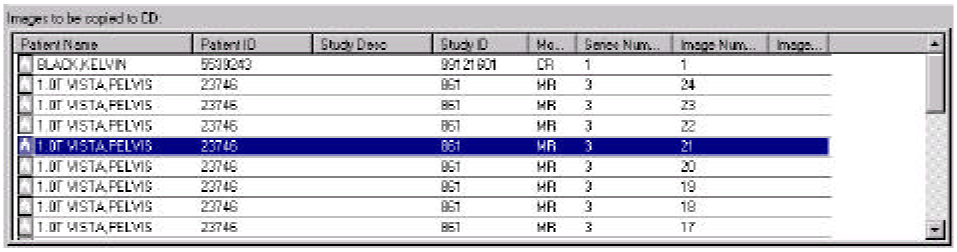
?? **Display All Images**—Invokes the function previously described on Page 37, Chapter 4D.2.b, Display Image(s), for all images listed in the window.

3. Images to be Copied to CD

The Images to be Copied to CD sub-window occupies the lower left portion of the main screen, as shown on Page 21, in Figure 4-4 Main Screen GUI. The **Images to be Copied to CD** sub-window organizes and displays images before creating storage sets.

a. Overview

The **Images to be Copied to CD** sub-window displays demographics information associated with image selections indicated in the **DICOM Image List** sub-window, as illustrated in Figure 4-64.



Images to be copied to CD:

Patient Name	Patient ID	Study Desc	Study ID	Mo...	Series Num...	Image Num...	Image...
BLACK,KELVIN	5539243		99121601	CR	1	1	
1.0T VISTA,PELVIS	23746		861	MR	3	24	
1.0T VISTA,PELVIS	23746		861	MR	3	23	
1.0T VISTA,PELVIS	23746		861	MR	3	22	
1.0T VISTA,PELVIS	23746		861	MR	3	21	
1.0T VISTA,PELVIS	23746		861	MR	3	20	
1.0T VISTA,PELVIS	23746		861	MR	3	19	
1.0T VISTA,PELVIS	23746		861	MR	3	18	
1.0T VISTA,PELVIS	23746		861	MR	3	17	

Figure 4-64 Images to be Copied to CD

The information listed for each image is identical to that provided in the **Detailed Image List** sub-window.

b. Operations

The **Images to be Copied to CD** sub-window performs various tasks in addition to displaying demographic information. Right clicking over a specific line (row) opens the popup menu illustrated in Figure 4-65. Highlighting the desired function and left clicking invokes the function.

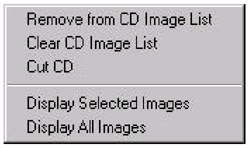


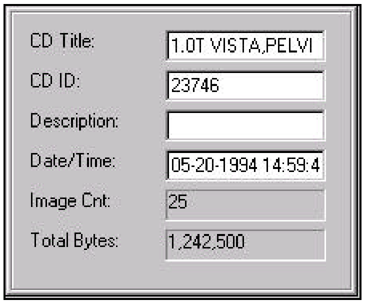
Figure 4-65 Images to be Copied to CD—Image Management Popup Menu

?? **Remove from CD Image List**—Invokes the function previously described on Page 38, Chapter 4D.2.d, Remove from CD Image List.
?? **Clear CD Image List**—Invokes the function previously described on Page 39, Chapter 4D.2.e, Clear CD Image List.
?? **Cut CD**—Invokes the function previously described on Page 39, Chapter 4D.2.f, Cut CD.
?? **Display Selected Images**—Invokes the function previously described on Page 37, Chapter 4D.2.b, Display Image(s), for the selected images.
?? **Display All Images**—Invokes the function previously described on Page 37, Chapter 4D.2.b, Display Image(s), for all images listed in the window.

4. CD Information Area

The CD Information Area sub-window occupies the lower right portion of the main screen, as shown on Page 21, in Figure 4-4 Main Screen GUI. The **CD Information Area** sub-window permits reviewing and editing information destined for media labels.

Refer to Figure 4-66. Information displayed in the top four lines (**CD Title**, **CD ID**, **CD Description**, and **Date/Time**) is taken from the DICOM header of the first image in the storage set. Unless edited, this becomes the information used for the custom label printed on media. Users can edit this information by selecting a field and altering alphanumeric strings. Information contained in the last two lines (**Image Cnt** and **Total Bytes**) is automatically generated by CD *Power*PACS software and is presented for information only.



CD Title: 1.0T VISTA,PELVI

CD ID: 23746

Description:

Date/Time: 05-20-1994 14:59:4

Image Cnt: 25

Total Bytes: 1,242,500

Figure 4-66 CD Information Area

G. Function Buttons

As previously indicated, the lower portion of the main window contains six Function Buttons. These buttons provide rapid access to functions previously identified. The six functions are:

1. Query

The **Query** Function Button invokes the **Query** function and opens the window illustrated as Figure 4-45 Query Window. This was previously described on Page 42, Chapter 4D.2.h, Query Local/Remote.

2. Add to CD

The **Add** to CD Function Button invokes the **Add** function, as previously described on Page 38, Chapter 4D.2.c, Add to CD Image List.

3. Remove

The **Remove** Function Button invokes the **Remove** function, as previously described on Page 38, Chapter 4D.2.d, Remove.

4. Display

The **Display** Function Button invokes the **Display** function and opens the window illustrated as Figure 4-35 Display DICOM Images Window. This was previously described on Page 37, Chapter 4D.2.b, Display Image(s).

5. Cut CD

The **Cut CD** Function Button begins the media writing process and opens the window illustrated as Figure 4-39 Cut DICOM Image CD. This was previously described on Page 39, Chapter 4D.2.f, Cut CD.

6. Exit

The **Exit** Function Button begins the **Exit** process and opens the window illustrated as Figure 4-32 Exit Confirmation Window. This was previously described on Page 36, Chapter 4D.1.e, Exit.

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Chapter 5 OPERATING PROCEDURES

A. *Introduction*

The following sections provide step-by-step instructions for performing the most common CD *Power*PACS operations associated with media creation. Due to the configurable, modular nature of the workstation, these are generic instructions; various steps might not apply to your specific configuration. These instructions are not the only way to accomplish the selected tasks. However, they provide a complete, logical, and sequential method covering the entire process from startup through media creation.

?? Startup.
?? Login.
?? Find Local Images.
?? Find Remote Images.
?? Select Images.
?? View Images.
?? Add Images to Storage Set.
?? Cut CD.

In addition, three administrative tasks are also described.

?? Add Workstation.
?? Add User.
?? Delete User.

B. *Startup*

The CD *Power*PACS Workstation should be started in the prescribed sequence to ensure proper operation.

NOTE

> The Media Writer must start and successfully complete self-tests before applying power to the CD *Power*PACS Workstation. The CD *Power*PACS Workstation **cannot** establish communications with the Media Writer until self-tests successfully complete. Starting the workstation before successfully completing Media Writer self-tests requires workstation and Media Writer shutdown and restart in the correct sequence.

Step	***Action***	***Result***
1.	Verify the following: ?? Media Writer OFF. ?? Computer OFF ?? Monitor OFF. ?? SCSI cable connected between Media Writer and computer with a terminator. ?? Monitor connected. ?? Network cable connected. ?? Surge protector connected. ?? UPS connected.	The CD *Power*PACS Workstation is ready to startup.

Step	Action	Result
2.	Apply power to the Media Writer.	The power light is ON. Status indicators on the Media Writer flash and mechanisms cycle. After a brief delay, Power On Self Testing completes. The device indicates ready for use.
3.	Apply power to the Monitor.	The power light is ON.
4.	Apply power to the Computer.	The power light is ON. Status indicators on the front panel flash, internal cooling fans hum, and internal hard drives "spin up." After a brief delay, Power On Self Testing completes and the box "beeps". The monitor displays various status indications. After a brief wait, the operating system login screen appears.

C. Login

When the Windows login screen appears, enter login and password information to connect the workstation with the network. If any login errors or status messages appear during startup, do **not** continue until problems are first resolved. From the Windows Login Window:

Step	Action	Result
1.	Select the Windows User Name field.	A cursor appears in the User Name field.
2.	Enter the case-sensitive User Name.	Clear text appears in the User Name field as text is entered.
3.	Select the Windows Password field.	A cursor appears in the Password field.
4.	Enter the case-sensitive Password.	Encrypted text (a series of asterisks) appears in the Password field as test is entered.
5.	Locate and select the **Enter** button.	Windows attempts to locate and validate the user account. After a brief delay, the desktop appears. Windows continues to load items in the background. The CD *Power*PACS application automatically loads and its Startup Screen & Login Window appear.
6.	Select the CD *Power*PACS User Name field.	A cursor appears in the CD *Power*PACS User Name field.
7.	Enter the case-sensitive User Name.	Clear text appears in the User Name field as text is entered.
8.	Select the CD *Power*PACS Password field.	A cursor appears in the CD *Power*PACS Password field.
9.	Enter the case-sensitive Password.	Encrypted text (a series of asterisks) appears in the Password field as test is entered.
10.	Locate and select the **Login** button.	The CD *Power*PACS application launches and the RADinfo Systems CD PowerPACS window opens.

D. Find Local Images

Images previously sent or automatically uploaded to the local hard drive from another DICOM workstation appear in the **DICOM Image List** area, under the **Local Storage** icon. However, the image on the monitor only updates upon operator command. Thus, images stored on the local hard drive might not appear under the **Local Storage** icon if they were sent after the last update. Perform the following to search for images on the local hard drive.

Step	***Action***	***Result***
1.	From the RADinfo Systems CD *Power*PACS Main Screen, left-click to select (highlight) the **Local Storage** icon.	The area surrounding the **Local Storage** icon turns blue to indicate selection.
2.	Rapidly double-click the **Local Storage** icon.	CD *Power*PACS scans the local hard drive and automatically updates the list of images in the local data base. After a brief delay, the List Tree in the **DICOM Image List** window refreshes to indicate all Studies, Series, and Images currently on the local hard drive.
3.	If necessary, shorten the list of images by selecting the **Query** Button at the lower left corner of the window. -or- Highlight the **Local Storage** icon by left-clicking on it. Once highlighted, then right-click on it to open a tracking menu. Left-click on the **Query Local Images** menu item.	The Query Window appears.
4.	Left-click and select the appropriate storage device under the **Resource** heading.	A drop down list appears, indicating all authorized storage devices. Scroll until **Local Storage** appears. Select (highlight) **Local Storage**.
5.	Determine which field will be used to query (filter) the data. Click in the button to the left of the name of the sort field.	The button changes. Unselected fields contain empty circles. Selected fields contain a bullet inside. The query fields are mutually exclusive; only one may be selected at a time. The title of the text entry heading changes to reflect the query filter selection.
6.	Left-click and select the text entry field.	A cursor appears text entry field.
7.	Enter sort/query data.	Text appears as typed.
8.	Select the **Query** Button.	CD *Power*PACS queries the **Local Storage** and returns a list of Studies, Series, Images matching criteria.
9.	If any Patient node in the tree control is not expanded, left-click on it to select it, then double click on it.	The application will query for study, series and image information for this patient, and adds it to the patient node

E. *Find Remote Images*

CD *Power*PACS attempts to locate images on remote workstations according to pre-configured schedules. Because of refresh constraints, the identities of Studies, Series , and Images existing at remote workstations may not have been transferred to the CD *Power*PACS. In such cases, it is necessary to update (refresh) the remote workstation name list. Perform the following to search for images on remote workstations.

Step	*Action*	*Result*
1.	From the RADinfo Systems CD *Power*PACS Main Screen, left click to select (highlight) a **Remote Workstation** icon.	The area surrounding the **Remote Workstation** icon turns blue to indicate selection.
2.	Rapidly double -click the **Remote Workstation** icon.	CD *Power*PACS queries the remote workstation automatically updates (refreshes) the list of images in the local data base. After a brief delay, the List Tree in the **Remote Workstation** window refreshes to indicate all Studies, Series, and Images currently on the remote hard drive.
3.	If necessary, shorten the list of images by selecting the **Query** Button at the lower left corner of the window. -or- Highlight the **Local Storage** icon by left -clicking on it. Once highlighted, then right-click on it to open a tracking menu. Left -click on the **Query Local Images** menu item.	The Query Window appears.
4.	Left -click and select the appropriate storage device under the **Resource** heading.	A drop down list appears, indicating all authorized storage devices. Scroll until the desired **Remote Workstation** appears. Select (highlight) the desired **Remote Workstation**.
5.	Determine which field will be used to query (filter) the data. Click in the button to the left of the name of the sort field.	The button changes. Unselected fields contain empty circles. Selected fields contain a bullet inside. The query fields are mutually exclusive; only one may be selected at a time. The title of the text entry heading changes to reflect the query filter selection.
6.	Left -click and select the text entry field.	A cursor appears text entry field.
7.	Enter sort/query data.	Text appears as typed.
8.	Select the **Query** Button.	CD *Power*PACS queries the **Remote Workstation** and returns a list of Studies, Series, Images matching criteria.

Step	*Action*	*Result*
9.	If any Patient node in the tree control is not expanded, left -click on it to select it, then double click on it.	The application will query for study, series and image information for this patient, and adds it to the patient node

F. Select Images From Detailed Image List

Image selection occurs after locating an image according to Storage Device, Patient Name, Series, and Individual Image. Perform the following to select an image or a set of images.

Step	*Action*	*Result*
1.	Scroll through the **DICOM Image List** Window or the **Detailed Image List** Window and locate the desired image(s).	~
2.	To select a single image, left -click the indicated image.	A single line (row) highlights.
3.	To select a range of adjacent images, left-click an item at either end of the range. Hold the **Shift** key and left -click the item at the end of the range.	A consecutive block of images highlight. The first and last items selected form the boundaries of the range.
4.	To select a range of non-adjacent images, left -click an item. Hold the **Ctrl** key and left -click the next desired item. Repeat the process until all desired items are selected.	A non-consecutive sequence of images highlight.

G. View Images

Clicking the **Display** Button at the bottom of the main window invokes the **Image Information** Window. All selected images appear in this window.

H. Add Images to Media

To add the selected images from the Detailed Image List to the **Images to be copied to CD** window, click the **Add to CD** Button at the bottom of the main window, or drag the selected images to the **Images to be copied to CD** window with the right button.

To add images directly from a node in the **DICOM Image List** tree to the **Images to be copied to CD** window, highlight an appropriate node with left button. Then drag it with the right button to the **Images to be copied to CD** window.

I. Cut CD

Clicking the **Cut CD** Button at the bottom of the main window begins the media writing process. All images in the storage set are processed. The **CD Task Dialog** window provides status of operations in progress.

J. Add Workstation

Administrative users sometimes add DICOM workstations to the configuration. While logged in as an Administrator, perform the following to add and configure a DICOM workstation.

Step	*Action*	*Result*
1.	Left-click the **File** menu selection.	The **File** menu appears.
2.	Locate and select **Configure**.	The **Configuration** Window appears.
3.	If not selected, select the **DICOM Network** Tab.	The **DICOM Network** Tab appears.
4.	Locate the Remote DICOM Node List at the right side of the screen.	~
5.	Enter the Host Name information in the **Host Name** field.	Text appears exactly as typed.
6.	Enter the TCP Port Number in the **TCP Port Number** field.	Text appears exactly as typed.
7.	Enter the AE Title in the **AE Title** field.	Text appears exactly as typed.
8.	Select the **Add** Button at the bottom, center of the window.	After a brief delay, the information appears as the text immediately below the **Remote DICOM Node List** header.
9.	Verify the information is correct.	~

K. Add User

Administrative users sometimes add other users to the configuration. While logged in as an Administrator, perform the following to add another user.

Step	*Action*	*Result*
1.	Left-click the **File** menu selection.	The **File** menu appears.
2.	Locate and select **User Accounts**.	The **User Accounts** Window appears.
3.	Enter the User Name information in the **User Name** field.	Text appears exactly as typed.
4.	Enter the Password in the **Password** field.	A series of asterisks appears in the field.
5.	Enter the Password in the **Confirm Password** field.	A series of asterisks appears in the field.

Step	*Action*	*Result*
6.	Enter the user' s full name in the **Full Name** field.	Text appears exactly as typed.
7.	Select either the **Normal User** or the **Administrative User** button.	The middle of the button fills to indicate selection.
8.	Select the **Add** Button at the bottom, center of the window.	After a brief delay, the information appears as the text at the list to the left of the screen.
9.	Verify the information is correct.	~

L. Delete User

Administrative users sometimes remove users from the configuration. While logged in as an Administrator, perform the following to delete a user.

Step	*Action*	*Result*
1.	Left-click the **File** menu selection.	The **File** menu appears.
2.	Locate and select **User Accounts**.	The **User Accounts** Window appears.
3.	Locate the desired user name in the list at the left of the window.	~
4.	Select the desired user name.	The selected row highlights. The text boxes at the right of the window fill with the selected user' s information.
5.	Verify the information is correct.	~
6.	Select the **Delete** Button at the bottom, center of the window.	After a brief delay, the information disappears from the list to the left of the screen.

Chapter 6 MAINTENANCE, TROUBLESHOOTING, AND MORE

A. Introduction

Maintenance and troubleshooting are factors users generally do not consider when dealing with workstations; they are usually forgotten until something goes wrong. This chapter deals with these necessary–albeit forgettable–topics.

B. Maintenance

CD *Power*PACS maintenance consists of routine operations performed by users. Perform these actions as needed.

?? Media Writing Device – Perform maintenance according to the manufacturer' s published schedules.
?? Monitor – Check the monitor screen for fingerprints, dust, or grim. Wipe the monitor glass with a clean, soft, dry cloth. Check the brightness and contrast settings to ensure legibility of displayed text. If necessary, after removing power, clean external plastic surfaces with a damp cloth.

?? Cables and Connectors – Ensure connectors are properly attached. Verify cables are correctly routed and check them for signs of wear or other damage.
?? Workstation Inspection – Visually inspect the workstation for signs of damage. If necessary, after removing power from the workstation, clean external plastic surfaces with a damp cloth.
?? UPS – Perform maintenance according to manufacturer's instructions. (If installed.)

C. Troubleshooting

Troubleshooting occurs in response to something going wrong. When a problem occurs, the most important thing to remember is: All technical problems can be resolved. A logical approach to troubleshooting helps to get the system back online as soon as possible.

1. Error Messages

The CD *Power*PACS application, the Media Writing Device interface software, and the Windows Operating System generate Error Messages to indicate the hardware experienced an unexpected problem, was not programmed to correctly resolve the issue, and needed operator involvement. Such messages may contain codes or option boxes. Error messages and displayed error codes should be written before attempting to clear the error condition. For isolated occurrences, the most appropriate action is to close the error message and follow the Initial Response Procedure.

2. Initial Response

In the absence of other indications, the most appropriate sequence of actions is to:

?? Exit the CD *Power*PACS application.
?? Exit Windows.
?? Shutdown the CD *Power*PACS Workstation.
?? Turn the Media Writing Device OFF.
?? Turn the Media Writing Device ON.
?? Wait 90-seconds.
?? Restart the CD *Power*PACS Workstation.
?? Ensure CD *Power*PACS Application properly launches.

In most cases, the problem disappears after rebooting the workstation *providing* the Media Writing Device is ON when the CD *Power*PACS Workstation restarts.

3. Unresponsive Workstation

The Initial Response procedure does not work if the workstation is hung, frozen, or otherwise unresponsive. Under these circumstances, perform the following actions:

?? Check the keyboard and mouse cables to the workstation.
?? Simultaneously press–and hold for 3 seconds–the **Ctrl-Alt-Delete** keys on the keyboard. Follow any onscreen instructions displayed.
?? If the workstation remains unresponsive, press the **Ctrl-Alt-Delete** keys for a second time.
?? If the workstation still remains unresponsive, press the **RESET** switch on the computer.
?? The workstation should reboot and launch the CD *Power*PACS application. However, the Media writing Device and the CD *Power*PACS application are not synchronized. It is necessary to shutdown the CD *Power*PACS Workstation and restart the system according to approved procedures.

If the problem continues, before proceeding with additional troubleshooting, document the symptoms, then perform a thorough inspection.

4. Document Symptoms

The next step toward recovery is to accurately document problem symptoms. As soon as possible, you should record:

?? What did you do?
?? What was expected?
?? What happened?
?? What error messages–if any–was displayed?
?? Was anything else effected?
?? What time did this happen?

This information should be kept at the workstation until the problem is resolved.

5. Thorough Inspection

A thorough inspection often yields valuable troubleshooting information, localizes problem areas, and prevents chasing ghosts through the system. It is recommended the following be checked in the sequence listed:

?? Cables – Ensure the Keyboard, Mouse, Monitor, NIC, Digitizer, and Modem cables are properly mated with the correct connector. Inspect connectors for broken, damaged, or bent pins.
?? Power Sources – Ensure power flow from the wall outlet to the workstation components. Ensure surge protectors are switched ON. Verify the UPS–if installed–is ON, with sufficient battery power, as evidenced by front panel indicators. Verify all power cords are fully inserted at the power source and the workstation component.
?? Monitor – Ensure the monitor powers ON, as evidenced by an illuminated power indicator. Listen to ensure the monitor makes a distinctive "static" sound when first applying power. In addition, the monitor displays a "loss of video signal" message/logo while the computer is OFF.
?? Computer – Ensure the computer powers ON, as evidenced by an illuminated power indicator. During boot sequence, ensure hard drive, CD-ROM, and NIC activity indicators illuminate.
?? Boot Sequence – Various logos and status messages appear on the monitor screen during the workstation startup sequence. When, the Windows login logo appears, enter login and password information to connect the workstation with the network. Note any login errors or status messages during startup.
?? CD *Power*PACS Launch – The CD *Power*PACS application should automatically launch. Note any errors in the launch sequence.

If you encounter a problem at any time, do not continue. Correct the known problem before proceeding to the next step.

6. Other Possibilities

In the unlikely event that the CD *Power*PACS application launches but does not run correctly, the most likely culprits are corrupted software, improper configuration, or network problems. Software problems are most expediently corrected by reloading from a known good installation program. Improper configuration is most expediently corrected by manually reconfiguring the workstation. Network problems are most expediently corrected by contacting the local help desk or network administrator.

7. Diagnostic Tools

Various software applications and hardware components provide diagnostic capabilities to further localize the problem.

a. Software Diagnostics

i. Windows OS

The Windows OS contains several utility programs designed to recover from disk and file system corruption. Instruction manuals and help files provided with the workstation descri be the use of each of these utilities.

ii. Anti-Virus

An Anti-Virus software application is factory loaded on the CD *Power*PACS Workstation. Running this application could resolve outstanding problems. It may be necessary to update virus definition files for maximum effectiveness.

b. Hardware Diagnostics

i. NIC Tools

When available, a diagnostic application is factory loaded on the CD *Power*PACS Workstation. Open this application to access diagnostic tests. Run the diagnostics according to manufacturer' s instructions.

ii. Modem Tools

When available, a diagnostic application is factory loaded on the CD *Power*PACS Workstation. Open this application to access diagnostic tests. Run the diagnostics according to manufacturer' s instructions.

D. Remote Access

CD *Power*PACS Workstations are optionally loaded with a remote access program. This program permits the RADinfo Systems Technical Support Department to access, control, diagnose, and repair your workstation under most circumstances.

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APPENDIX A: GLOSSARY

Term	*Definition*	*Explanation*
ACR	American College of Radiology.	
ADT	Admission, Discharge & Transfer	~
AE	Application Entity	Description used to uniquely identify a workstation.
Alt	Alternate.	Key adjacent to the space bar on the keyboard.
CD	Compact Disc	Read-only storage device used to load data or programs onto a workstation.
CENTREX	CENTRal Exchange	Telephone switch that requires dialing a prefix to get an outside line.
COM	COMmunications Port	Serial port used by computers to communicate with external devices.
COMPL	Completed	~
CPU	Central Processing Unit	The "brains" of a computer.
CR	Computed Radiography	Medical imaging device.
Ctrl	Control	Key at the lower-right or lower-left corner on the keyboard.
DICOM	Digital Imaging and Communications in Medicine	Medical standard jointly developed by American College of Radiologists and the National Electronics Manufacturing Association.
dpi	Dots Per Inch	Measure of optical scanning resolution.
DSL	Digital Service (Subscriber) Line	High-speed digital data line.
DUN	Dial-Up Network	Windows communication interface designed to initiate PPP connections.
DUS	Dial-Up Server	Windows communication interface designed to receive PPP connections.
FD	Film Digitizer	~
GB	Giga Bytes	Measurement for data storage units. Approximately 1,000,000,000 units.
GUI	Graphical User Interface	Visual interface used by application programs, features buttons and icons to represent instructions.
HHMMSS	Hour-Minute-Second	Time Format.
HT	Howtek	A Film Digitizer hardware manufacturer for the MultiRad product line.
HIS	Hospital Information Systems	Hospital's patient and workflow management system.
INTER2000	INTER2000 *Film Digitizer*	A DICOM application program developed by Radiology Information Systems.
IDT	ID Terminal	Fuji medical device.
IMG	Image	~
ISDN	Integrated Services Digital Network	High-speed digital data line.
JPEG	Joint Photographic Expert Group	Standards committee for photographic images.
kB	kilo Bytes	Measurement for data storage units, approximately 1,000 units.
MB	Mega Bytes	Measurement for data storage units, approximately 1,000,000 units.

Term	*Definition*	*Explanation*
MBPS	Mega Bits Per Second	Measurement for data transfer, approximately 1,000,000 units per second.
MHz	Mega Hertz	Measurement for frequency, equal to 1,000,000 cycles per second.
MWL	Modality Worklist	~
NIC	Network Interface Card	Device used to connect a workstation to a computer network.
OS	Operating System	Software for a CPU.
PACS	Picture Archive and Communications Standard	Medical standard.
PBX	Private Branch eXchange	Telephone switch that requires dialing a prefix to get an outside line.
PC	Personal Computer	Originally *Personal Computer*, now a generic term used to indicate most desktop computers in use today.
PCI	Peripheral Communications Interface	Computer standard.
PCMCIA	~	Hardware standard used with laptop/portable computers.
PPP	Point-to-Point Protocol	Dial-Up protocol set used to control and transmit data between workstations.
QA	Quality Assurance	~
QC	Quality Control	~
RAM	Random Access Memory	Type of memory device contained within a workstation.
RIS	Radiology Information Systems	Radiology Department's patient and workflow management system.
RADinfo Systems	Radiology Information Systems, Inc.	Software developer of the RSVS, I2000, and CD *Power*PACS solutions.
ROI	Region Of Interest	Area of special concern identified for spot scans while digitizing film.
SCSI	Small Computer System Interface	Communication and connection standard used to transmit data between a computer and a peripheral device or to control a peripheral device (e.g. Film Digitizer).
SCP	Service Class Provider	DICOM term designating a unit's ability to receive and process data.
SCU	Service Class User	DICOM term designating a unit's ability to requests services from an SCP.
SOP	Service Object Pair	DICOM service object designation.
TCP/IP	Transmission Control Protocol/ Internet Protocol	Protocol set used to control and transmit data between workstations.
TELCO	Telephone Company.	~
TWAIN	~	Industry interface standard for scanning/ digitizing devices.
UID	Unique IDentifier	DICOM Class or object instance identifier.
UPS	Uninterruptible Power Supply	Battery-operated device used to isolate, regulate, and condition power.
WLM	Worklist Manager	~
W/L	Window and Level	Brightness and contrast setting used with image display.
YYYYMMDD	Year-Month-Day	Date format.

APPENDIX B: ERROR CODES

Error Code or Text	*Explanation*	*Corrective Action*
0I	OK	Status message. No Action Required.
1	Bad Parameter	Internal computational error. Try again. Contact RADinfo Systems if this persists.
2	Bad Data	
3	Item not found	
4	Item unknown	
5	Bad internal data	
6	Bad item length	
7I	Empty line	
8	Internal error	
9	Bad operation	
10	Bad item	
11	Bad format	
12	Not initialized	
101	Free memory	Memory error. Try again. Contact RADinfo Systems if this persists.
102	Alloc memory	
103	Get Memory ID	
104	Buffer over flow	
105	Exceed boundary	
106	Pool over flow	
201	Open file	Windows file system error. Try again. Contact RADinfo Systems if this persists.
202	Read file	
203	Write file	
204I	End of file	
205I	End of line	
206I	End of item	
207I	End of group	
208	Bad file format	
209	Bad file data	
210	No match	
211	Find file	
212	File already exist	
301I	Not applied	Windows data structure error. Try again. Contact RADinfo Systems if this persists.
302	Not supported	
303	Attribute missing	
304	Condition not set	
305I	End of buffer	
306I	No data set	
307I	Update	
308I	End of bitmap	
309I	No action	
310I	NULL region	

Error Code or Text	*Explanation*	*Corrective Action*
401	Open dialog	Windows internal communication (system - level) error. Try again. Contact RADinfo Systems if this persists.
402	Retrieve dialog item	
403	Get control	
404	Create DC	
405	Delete DC	
406	Print	
407	Create font	
408	Windows API	
409	Get font info	
410	Dial Up Error	Dial-Up Network error. Use Dial-Up Network item to attempt to establish direct modem connection.
501	Image size too large	Internal memory error (image data format). Try again. Contact RADinfo Systems if this persists.
502	Get bitmap	
601	File info	Windows status messages. Contact RADinfo Systems if this persists.
602	Bad object type	
603I	Hit test	
604I	Hit test at non interest area	
605I	Call next process	
606I	Do not call next process	
607I	End enum process	
701	Find host	TCP/IP configuration or connection error. Check DICOM Peer Node destination. Check Dial-Up destination. Check Config DICOM Node entries. Check TCP/IP address in Dial-Up items. Check hosts file. Contact RADinfo Systems is this problem persists.
702	Connect TCP	
703	Bad socket	
704	Get socket	
705	Invalid set	
706	Unknown shutdown	
707	Comm not complete	
708	Net connected	
709	Unknown Socket close	
710	Receive data	
711	TCP Send size	
712	Set TCP linger	
713	Set TCP Send Buffer	
714	Set TCP recv buffer	
715	TCP recv data	
716	Init network	
717	Socket closed	
718	Send time out	
719	Recv time out	
720	Bad network data	
721	TCP Select	
722	Clean up TCP	
723	Close socket	
724	No connection	
725	Set socket option	
726	Unknown remote	
727	Bind socket	

Error Code or Text	*Explanation*	*Corrective Action*
728	Listen socket	
801	Item type unknown	DICOM Network and Application Layer errors. Contact RADinfo Systems if this persists.
802	Too many app ctx	
803	Too many user info	
804	Duplicated elem	
805	Bad attribute	
806	PDU type unknown	
807	Assoc failed	
808	Echo RSP	
809	Release RSP	
810	Store RSP	
811	Duplicated tag item	
812	Find RSP	
813	Find RSP Status	
814	Find RSP Data	
815	Get RSP	
816	Get RSP Status	
817	Get RSP Data	
818I	Query Retrieve complete	
819I	Store suboperation	
820	Move RSP	
821	Move RSP Status	
822	Move RSP Data	
823I	Assoc terminated	
824	Bad data length	
1001I	Send succeeded	Status messages. No action required.
1002I	Echo Succeeded	
1003I	Pending	

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APPENDIX C: SITE SURVEY WORKSHEET

?? RADinfo Systems WORKSTATION

?? Customer ID ____________________
?? Customer Name ____________________
?? Address 1 ____________________
?? Address 2 ____________________
?? City, State Zip ____________________
?? Physical Description ____________________
?? TCP/IP Address ____________________
?? Port Number ____________________
?? Host Name ____________________
?? AE Title ____________________
?? Dial Up Number ____________________
?? Contact Name ____________________
?? Contact Number ____________________
?? Conditioned Power Yes // No
?? Adequate Ventilation Yes // No
?? Adequate Area Yes // No
?? Phone Line Tested Yes // No // NA

?? DICOM Peer Nodes

Item	**Node #1**	**Node #2**	**Node #3**
Physical Description			
Modality Type			
Manufacturer			
Model			
TCP/IP Address			
Port Number			
Host Name			
AE Title			
Dial-Up Number			

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APPENDIX D: HARDWARE & SOFTWARE REQUIREMENTS

A. *CD Power*PACS *System Software*

?? Windows Operating System:

✍✍ Windows NT 4.0.

✍✍ Windows 2000 Server.

?? Application Software

✍✍ RADinfo Systems CD *Power*PACS Software v1.00.

✍✍ Media Writing Device Application Software with compatible drivers.

B. *CD Power*PACS *System Hardware* [1] [2]

1. CD *Power*PACS 1000 System

✍✍ Control Center: High performance DELL expandable server system. Minimal System: Intel Pentium III Processor (>700 MHz), 128 MB RAM, ?20 GB Hard Drive, 3-1/2” Floppy Diskette Drive, ?40x CD ROM, ?16 MB Video Display Driver Card, 56k/v.90 Internal Modem, 10/100 BaseT Network Interface Card. 18" H x 8" W x 18" D (46cm H x 20cm W x 46cm D), 42 lbs. (19Kg).

✍✍ Monitor: Dell color display, 15" H x 15" W x 15" D (38cm H x 38cm W x 38cm D), 30 lbs. (14Kg). With optional upgrade to flat panel display.

✍✍ Drive: Single 12X CD-R recorder.

✍✍ Bin Capacities: Three 60-disc bins configurable as input, output, or reject. Maximum IO capacity is approximately 120 discs.

✍✍ Prism CD Printer: 300 dpi color thermal transfer CD printer.

✍✍ Ribbons: CMY paneled ribbon or one color ribbon .

✍✍ Perfect Print Function: Enables to align customized graphics and text to pre-silk screened CD-R’s that reflect required standard colors, logos, and graphics.

✍✍ Automation Station: 17 1/2"H X 15"W X 22 1/2"D, (44.5cm H X 37cm W X 57cm D), 62 lbs. (27Kg). Shipping wt. 72 lbs. (32 Kg).

2. CD *Power*PACS 2000 System

✍✍ Control Center: Standard Dell tower packaging. Minimal System: Intel Pentium III Processor (>700 MHz), 128 MB RAM, ?20 GB Hard Drive, 3-1/2” Floppy Diskette Drive, ?40x CD ROM, ?16 MB Video Display Driver Card, 56k/v.90 Internal Modem, 10/100 BaseT Network Interface Card. 18" H x 8" W x 18" D (46cm H x 20cm W x 46cm D), 42 lbs. (19Kg).

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[1] RADinfo Systems currently features Rimage Corporation and Dell Dimension, Optiplex, and Power Edge computers, typically with components from the following manufacturers: 3COM, Adaptec, American Power Conversion (APC), ATI Rage, Belkin, Diamond Multimedia, harmon/kardon, Intel, Rorke Data, Seagate, Sound Blaster, and US Robotics.

[2] RADinfo Systems reserves the right to substitute comparable equipment and components, as availability requires.

✍✍Monitor: Dell color display, 15" H x 15" W x 15" D (38cm H x 38cm W x 38cm D), 30 lbs. (14Kg). With optional upgrade to flat panel display.

✍✍Drive: Two 12X CD-R recorders.

✍✍Bin Capacities: Three 60-disc bins configurable as input, output, or reject. Maximum IO capacity is approximately 120 discs.

✍✍Prism CD Printer: 300 dpi color thermal transfer CD printer.

✍✍Ribbons: 3-color panel ribbon, black, red, blue also available.

✍✍Perfect Print Function: Enables to align customized graphics and text to pre-silk screened CD-R’ s that reflect required standard colors, logos, and graphics.

✍✍Automation Station: 20"H X 13.5"W X 23"D, (61cm H X 34cm W X 58cm D), 85 lbs. (39Kg).

3. CD *Power*PACS 3000 System

✍✍Control Center: High performance DELL expandable server system. Minimal System: Intel Pentium III Processor (>700 MHz), 128 MB RAM, ?20 GB Hard Drive, 3-1/2” Floppy Diskette Drive, ?40x CD ROM, ?16 MB Video Display Driver Card, 56k/v.90 Internal Modem, 10/100 BaseT Network Interface Card. 17" H x 9.5" W x 17" D (43cm H x 24cm W x 43cm D), 42 lbs. (19Kg).

✍✍Monitor: 13.4" H x 13.8" W x 15" D (34cm H x 35cm W x 38cm D), 24 lbs. (11Kg). With optional upgrade to flat panel display.

✍✍Drive: two or four 12X CD-R recorders.

✍✍Bin Capacities: Three 60-disc bins configurable as input, output, or reject. Maximum IO capacity per Autostar is approximately 120 discs.

✍✍Prism CD Printer: 300 dpi color thermal transfer CD printer.

✍✍Ribbons: 3-color panel ribbon, black, red, blue also available.

✍✍Perfect Print Function: Enables to align customized graphics and text to pre-silk screened CD-R’ s that reflect required standard colors, logos, and graphics.

✍✍Automation Station: 23" H x 14.5" W x 27" D (58 cm H x 37 cm W x 69 cm D), 100 lbs. (45 Kg).

4. CD *Power*PACS *80* System

✍✍Control Center: High performance DELL expandable workstation system. Minimal System: Intel Pentium III Processor (>933 MHz), 128 MB RAM, ?36 GB Hard Drive, 3-1/2” Floppy Diskette Drive, ?40x CD ROM, ?16 MB Video Display Driver Card, 56k/v.90 Internal Modem, Onboard Intel Pro 100+ Network Interface Card. 17" H x 9.5" W x 17" D (43cm H x 24cm W x 43cm D), 42 lbs. (19Kg).

✍✍Interfaces: SCSI-2 recorder, serial robotics.

✍✍Monitor: 13.4" H x 13.8" W x 15" D (34cm H x 35cm W x 38cm D), 24 lbs. (11Kg). With optional upgrade to flat panel display.

✍✍Drive: Single 12X CD-R recorder.

✍✍Bin Capacities: 60 discs configured as input/output hopper. SCSI controlled robotics.

✍✍CD Printer: 1200 dpi full color mini-din controlled Centronics or Apple Serial printer.

✍✍Automation Station: 15"H X 11"W X 22"D, 30 lbs.

5. CD *Power*PACS *100* System

✍✍Control Center: High performance DELL expandable workstation system. Minimal System: Intel Pentium III Processor (>933 MHz), 128 MB RAM, ?36 GB Hard Drive, 3-1/2" Floppy Diskette Drive, ?40x CD ROM, ?16 MB Video Display Driver Card, 56k/v.90 Internal Modem, Onboard Intel Pro 100+ Network Interface Card. 17" H x 9.5" W x 17" D (43cm H x 24cm W x 43cm D), 42 lbs. (19Kg).

✍✍Interfaces: SCSI-2 recorder.

✍✍Monitor: 13.4" H x 13.8" W x 15" D (34cm H x 35cm W x 38cm D), 24 lbs. (11Kg). With optional upgrade to flat panel display.

✍✍Drive: Two 12X CD-R recorder.

✍✍Bin Capacities: 50 discs configured as input/output hopper, 5 discs reject hopper, SCSI controlled robotics, ionized brush cleaning system.

✍✍CD Printer: 1200 dpi full color mini-din controlled Centronics or Apple Serial printer.

✍✍Automation Station: 17"H X 11"W X 18"D, 30 lbs.

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APPENDIX E: GENERIC WORKSTATION STARTUP SEQUENCE

This Appendix describes a generic startup sequence associated with a correctly configured CD *Power*PACS Workstation. While this simplified description is neither complete nor completely accurate, it provides a general description of the background processes necessary to properly launch the CD *Power*PACS application. This description is provided only for general information and basic reference. Recall that all required hardware and software items are properly loaded and configured at RADinfo Systems before the CD *Power*PACS Workstation leaves the installation floor, and that these items should not be altered without express permission from the RADinfo Systems technical staff.

As previously indicated, the CD *Power*PACS Workstation contains a media-writing device. When this is an external device, this unit must be turned ON (power applied) *before* applying power to the CD *Power*PACS Workstation. In addition, this device and its associated drivers must successfully load before the CD *Power*PACS software application launches. In general, the following sequence must successfully complete before the CD *Power*PACS software correctly operates:

?? External Media-Writing Device ON.

?? Workstation ON.

?? SCSI Controller Loads.

?? Operating System Loads.

?? Operating System Login.

?? Desktop Appears.

?? Media Writing Software Loads.

?? CD *Power*PACS Software Loads.

A. External Media-Writing Device ON

Because of protocols used and the resulting interactions between hardware devices, the external media-writing device must be on before the CD *Power*PACS Workstation receives power. In general, the media device should finish its POST (Power On Self Test) routines *before* the CD *Power*PACS Workstation receives power. Any error indicators (i.e., flashing warning lights) should be investigated and resolved prior to powering the CD *Power*PACS Workstation.

B. Workstation ON

The CD *Power*PACS Workstation computer and monitor receive power and startup, as would any computer. The normal sequence is to start the monitor, then start the workstation. Various text messages and graphics appear during the startup sequence. These indicate the hardware and software devices currently being loaded by the operating system.

C. SCSI Controller—Command Line Startup Information

Most media-writing devices conform to the SCSI (Small Computer System Interface) standard. SCSI (pronounced *skuzzy*) devices require a specialized controller (hardware device) located in the CD *Power*PACS Workstation.

Software for the SCSI controller automatically loads when the workstation first starts. Command line displays during the startup process provide confidence that the SCSI controller software loads. A generic message similar to the one following appears.

```
Adaptec AHA-2940AU SCSI BIOS Version X.XX
C 1997 Adaptec, Inc. All Rights Reserved
<<<Press <Ctrl> <A> for SCSI Select TM Utility!>>>
SCSI ID: #4 MEDIA DEVICE NAME MODEL NUMBER DESCRIPTION

SCSI BIOS INSTALLED SUCCESSFULLY
```

The first line identifies the SCSI hardware in the workstation. The presence of these lines indicates the SCSI hardware is present and functioning in the workstation. The fourth line indicates the SCSI hardware successfully communicated with the media-writing device. This line also describes the device. The last line indicates the SCSI interface is functional.

The form, format, and information content of this presentation vary by device and configuration.

D. Operating System Loading, Login, and Desktop

The CD *Power*PACS workstation operating system (OS) continues to load after the SCSI controller loads. The load sequence pauses when the login screen appears. The OS prompts the user to enter a name and password. After validating these, the sequence continues and the desktop appears.

E. Media Writing Software

After the desktop appears, the OS continues to load software drivers and applications items identified in the Startup Item folder. In this case, the OS loads various software applications used to interface the CD *Power*PACS application to the media-writing device, as illustrated in Figure F-1. The DICOM CD icon at the lower right corner of the illustration launches the CD *Power*PACS application. The other three icons launch drivers and applications required to automate the media creation process and to control media-writing devices.

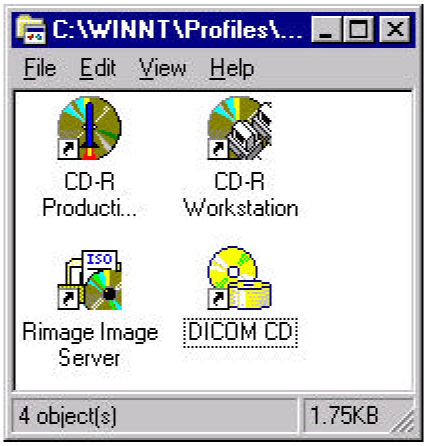
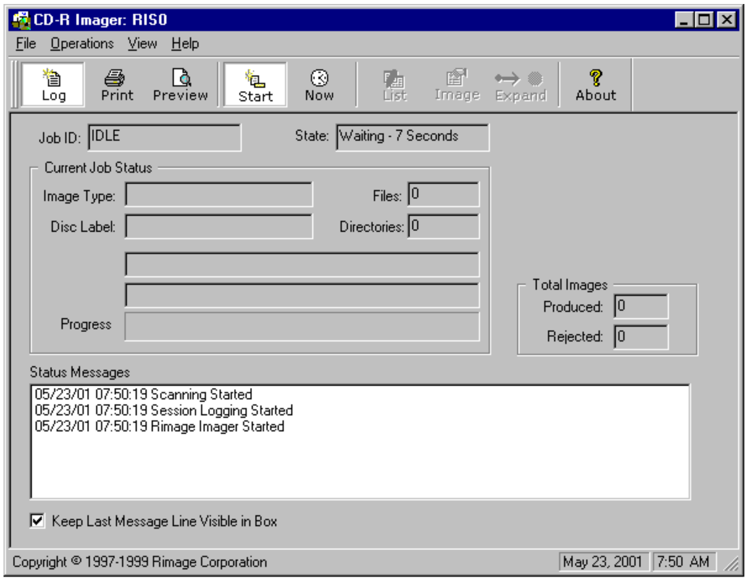


Figure F- 1 Startup Item Icons

The CD *Power*PACS workstation loads an application associated with Storage Set creation before loading other background applications. Figure F-2 represents a typical display associated with this event. This window is normally not seen by operators. Settings available in this window must not be altered without the express permission of RADinfo Systems technical staff.



CD-R Imager: RISO
File
Operations
View
Help
Log
Print
Preview
Start
Now
List
Image
Expand
About
Current Job Status
Image Type:
Disc Label:
Progress
Total Images
Status Messages

Job ID: IDLE

State: Waiting - 7 Seconds

Files: 0

Directories: 0

Produced: 0

Rejected: 0

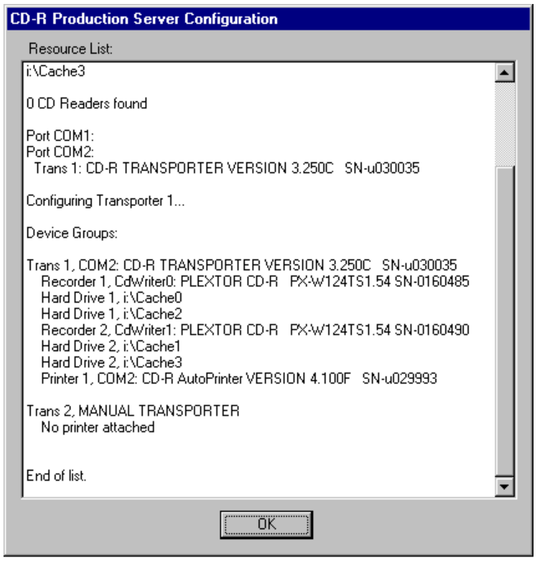
```
05/23/01 07:50:19 Scanning Started
05/23/01 07:50:19 Session Logging Started
05/23/01 07:50:19 Rimage Imager Started
```

☑ Keep Last Message Line Visible in Box

Copyright © 1997-1999 Rimage Corporation May 23, 2001 7:50 AM

Figure F- 2 Imager Startup Screen 1

The CD *Power*PACS workstation also loads software required to control the media-writing device. Figure F- 3 represents a typical display associated with this event. This particular illustration indicates the software searched all communication interfaces for suitable devices. In addition, this display also indicates that there is a dual media -writing device with a printer (Transport 1).

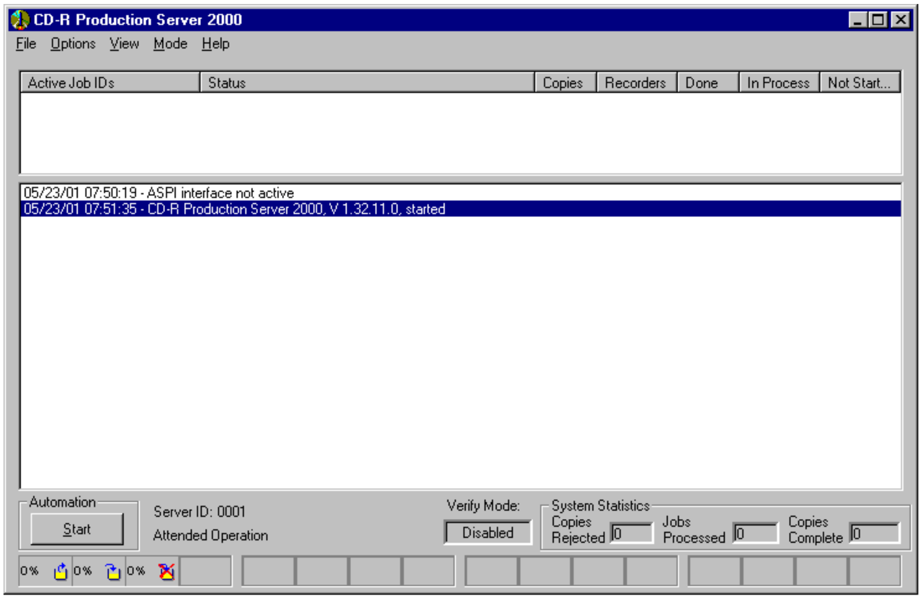


CD-R Production Server Configuration
Resource List:
OK

```
i:\Cache3

0 CD Readers found

Port COM1:
Port COM2:
  Trans 1: CD-R TRANSPORTER VERSION 3.250C   SN-u030035

Configuring Transporter 1...

Device Groups:

Trans 1, COM2: CD-R TRANSPORTER VERSION 3.250C   SN-u030035
    Recorder 1, CdWriter0: PLEXTOR CD-R   PX-W124TS1.54 SN-0160485
    Hard Drive 1, i:\Cache0
    Hard Drive 1, i:\Cache2
    Recorder 2, CdWriter1: PLEXTOR CD-R   PX-W124TS1.54 SN-0160490
    Hard Drive 2, i:\Cache1
    Hard Drive 2, i:\Cache3
    Printer 1, COM2: CD-R AutoPrinter VERSION 4.100F   SN-u029993

Trans 2, MANUAL TRANSPORTER
    No printer attached


End of list.
```

Figure F- 3 Production Server Startup Screen 1

After locating all suitable media -writing devices, the software controlling the media -writing process provides indication that automated media -writing is available. Figure F- 4 represents a typical display associated with this event. This particular illustration indicates the software has no jobs pending and is awaiting input from the CD *Power*PACS application. Settings available in this window must not be altered without the express permission of RADinfo Systems technical staff.


CD-R Production Server 2000
File Options View Mode Help
Active Job IDs
Status
Copies
Recorders
Done
In Process
Not Start...
Automation
Start
System Statistics
0%
0%
0%

05/23/01 07:50:19 - ASPI interface not active
05/23/01 07:51:35 - CD-R Production Server 2000, V 1.32.11.0, started

Server ID: 0001
Attended Operation
Verify Mode: Disabled
Copies Rejected 0
Jobs Processed 0
Copies Complete 0

Figure F- 4 Production Server Startup Screen 2

F. CD *Power*PACS *Software*

After all other background drivers, processes, and applications load, the CD *Power*PACS workstation loads the CD *Power*PACS application, as indicated by the presence of the Startup Screen & login Window. (Refer to Figure 4-1 Startup Screen and Figure 4-2 Login Window, Chapter 4B, beginning on Page 19.)

RADinfo SYSTEMS

CD PowerPACS™

QUICK START GUIDE

VIEW & SEND STATION

VIEWING
BURNING

RADinfo Systems, Inc.
2411 Dulles Corner Park
Suite 140
Herndon VA 20171
(703) 713-3313 voice
(703) 713-3343 fax

www.radinfosystems.com

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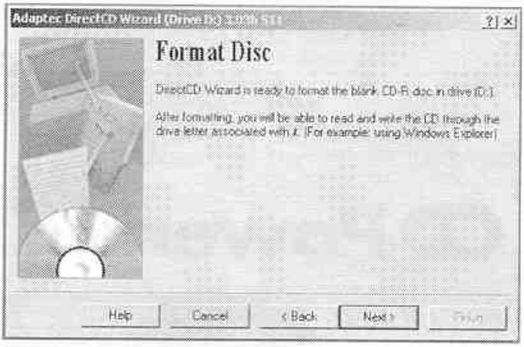
CD CREATE (Burn) INSTRUCTIONS

NEW CD (Direct CD)

When a new CD is placed in the drive, a screen will display "FORMAT Disc" click OK. When complete click OK.


Adaptec DirectCD Wizard (Drive D:)
?
×
Help
Cancel
< Back
Next >
Finish

Format Disc

DirectCD Wizard is ready to format the blank CD-R disc in drive (D:).

After formatting, you will be able to read and write the CD through the drive letter associated with it. (For example: using Windows Explorer)

KODAK Application

Drag images to the (Power Pacs Node) Then Images will be transferred to the RSVS Work list (this process will take a few minuets)

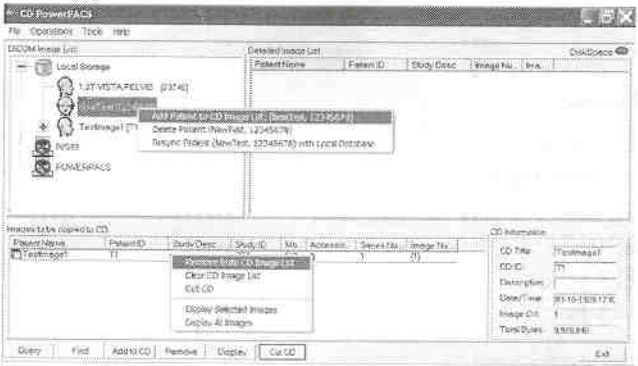
Switch to RSVS

Alt+Tab key then select the RSVS Icon

CD Creation (Burning)

Add to CD Image List

1. Right mouse click the study. The "Add Patient to CD image list" command inserts selected Studies, Series, and Images into the current storage set. Select a Study

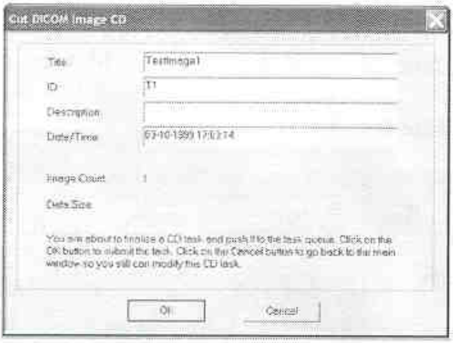

CD PowerPACS
File
Operations
Tools
Help
DICOM Image List
Local Storage
1.5T VISTA PELVIS
Testimage1
POWERPACS
Detailed Image List
DiskSpace
Patient Name
Patient ID
Study Desc
Image Nu
Add Patient to CD Image List
Delete Patient
Resync Patient with Local Database
Images to be copied to CD
Accession
Series No
Image No
Remove from CD Image List
Clear CD Image List
Cut CD
Display Selected Images
Display All Images
CD Information
CD Title
CD ID
Description
Date/Time
Image Cnt
Total Bytes
Query
Find
Add to CD
Remove
Display
Cut CD
Exit

2. Remove from CD Image List

To Remove an image from the CD List, Right Mouse click the Images to be removed Copied to CD window.

3. To CUT CD Click the CUT CD button.

CD information



Title: Testimage1

ID: T1

Description:

Date/Time: 03-10-1999 17:02:14

Image Count: 1

Data Size:

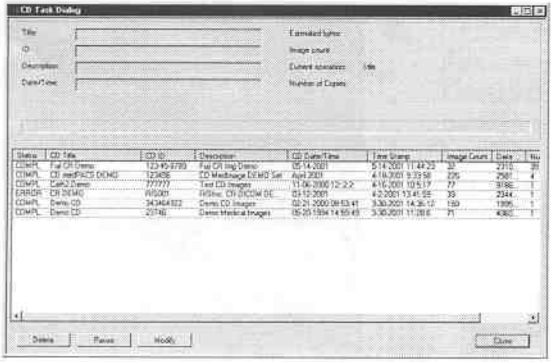
You are about to finalise a CD task and push it to the task queue. Click on the OK button to submit the task. Click on the Cancel button to go back to the main window so you still can modify this CD task.

- Title—Unless altered, this is the patient name of the first study selected in the storage set, as taken from the associated DICOM header.
- ID—Unless altered, this is the Patient ID of the first patient selected in the storage set, as taken from the associated DICOM header.
- Description—Alphanumeric description of the study. Unless altered, this is the description of the first study selected in the storage set, as taken from the associated DICOM header.
- Date/Time—The date and time of image creation *at the imaging modality*. The date follows a MM-DD-YYYY format. The Time follows a HH:MM:SS format, using a 24-hour clock.

Text may be changed prior to beginning the media writing process. Whatever appears in these lines appears on the media label.

The middle portion of the window displays the number of images in the storage set (Image Count) and the aggregate size of all images contained in the storage set (Data Size), indicated in bytes.

4. CD Task Dialog Status Messages



Title:

ID:

Description:

Date/Time:

Estimated bytes:

Image count:

Current operation: Idle

Number of Copies:

Status	CD Title	CD ID	Description	CD Date/Time	Time Stamp	Image Count	Data
COMPL	Full CR Demo	123-45-6789	Full CR Img Demo	05-14-2001	5-14-2001 11:44:23	37	2310
COMPL	CD medPACS DEMO	123456	CD MedImage DEMO Set	April 2001	4-18-2001 9:33:58	226	2581
COMPL	CaM2 Demo	777777	Test CD Images	11-06-2000 12:2:2	4-16-2001 10:5:17	77	9786
ERROR	CR DEMO	R/S001	R/Sinc. CR DICOM DE	03-12-2001	4-2-2001 13:41:55	33	2344
COMPL	Demo CD	343464322	Demo CD Images	02-21-2000 08:53:41	3-30-2001 14:36:12	150	1395
COMPL	Demo CD	23746	Demo Medical Images	05-20-1994 14:59:49	3-30-2001 11:28:6	71	4382

The large, middle portion of Task Dialog Window provides a detailed list of tasks. Each task occupies a single row. Tasks are nominally organized according to task creation, with the most recent task at the top of the list. A sliding bar at the bottom of this portion permits repositioning the window to view all displayed data.

Headers at the top of each column identify information according to:

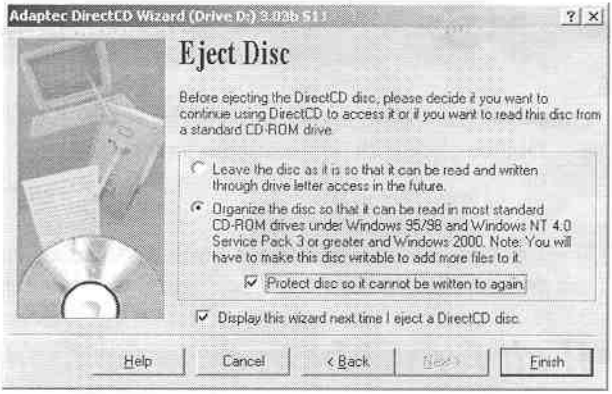
- Status—Single-word description of task status.
  PROC = (PROCESSING) Identifies tasks currently executing or waiting in the queue.
  COMPL = (COMPLETED) Task completed without error.
  ERROR = (ERROR) Task terminated before completion.

Complete CD (Adaptec Direct CD)

After all images and data have been transferred to the CD-R, double click the small Direct CD icon in the bottom right portion of the taskbar.

The Adaptec Direct CD Wizard – welcome dialog will display. Click the Next button. On the Drive Information Dialog Screen.

■ Finalize to read in most CD Readers *(This one **must** be checked)*



Eject Disc

Before ejecting the DirectCD disc, please decide if you want to continue using DirectCD to access it or if you want to read this disc from a standard CD-ROM drive.

○ Leave the disc as it is so that it can be read and written through drive letter access in the future.

● Organize the disc so that it can be read in most standard CD-ROM drives under Windows 95/98 and Windows NT 4.0 Service Pack 3 or greater and Windows 2000. Note: You will have to make this disc writable to add more files to it.

☑ Protect disc so it cannot be written to again.

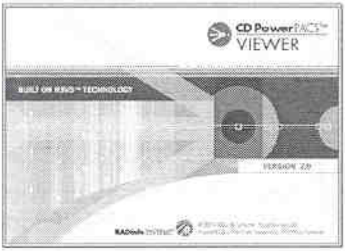
☑ Display this wizard next time I eject a DirectCD disc.

Click Finish.

The CD will Finalize and Eject upon Completion
CD is ready for Viewing on any PC.

* Pushing the Eject button on the CD Drive will always cause an error
Try to avoid using it.

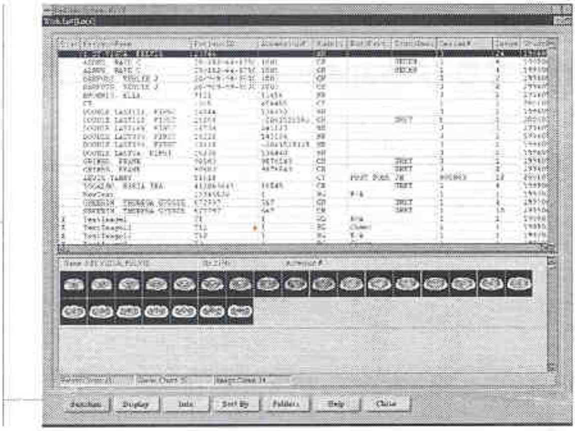
Viewing CD


CD PowerPACS™
VIEWER
BUILT ON RSVS™ TECHNOLOGY
VERSION 2.0

After you have Created a CD , use this Quick Start Guide to get you through images with RSVS software.

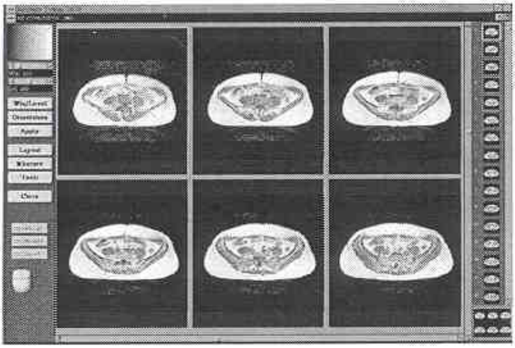
Insert the CD into the CDRom Drive, the RSVS software will automatically start.

(if the CD does not Auto Start, go to My Computer, double Click CD-Rom drive then double click the RSVS.exe icon)


Function
Display
Info
Sort By
Folders
Help
Close

1. From worklist, highlight patient name(s)
   a. Double click with left mouse button.
   or
   b. Click **Display** at the lower portion of the screen, once with left mouse button.

Wait for all Images to be displayed



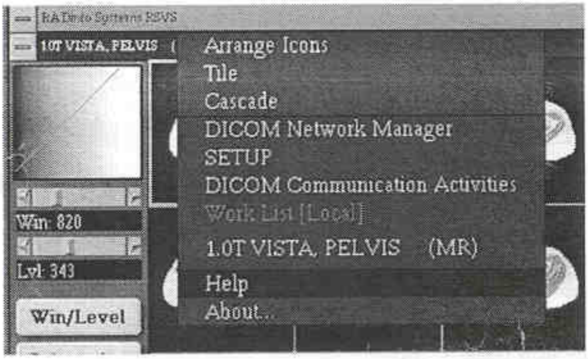
2. (If there is more than one image) Use the Right mouse button to highlight the image you want to work with.

3. **Most Used Functions:**

- To **Magnify**, Press and hold the Right mouse Button.
- To **Pan the Screen**, Press and hold the Left Mouse Button.
- To **Change the Window Level**, of an image. Press and hold both left and right mouse buttons at the same time.

4. For additional on-line help, click on the Title Bar with the left Mouse Button.

Title Bar ↓


RADinfo Systems RSVS
10T VISTA, PELVIS
Win: 820
Lvl: 343
Win/Level
Arrange Icons
Tile
Cascade
DICOM Network Manager
SETUP
DICOM Communication Activities
Work List [Local]
1.0T VISTA, PELVIS (MR)
Help
About...

With the Left mouse button click on "Help"

To return to the worklist, Press the **Close** button once with the left mouse button.

Adaptec Direct CD is a Copyright of Roxio, inc
Kodak Imager is Copyright of Kodak, Inc.

26 June 2002.

HF100H SERVICE MANUAL

This manual is established for repair•adjustment of the MinXray model HF100H portable x-ray unit. Copy and transfer without notice is prohibited.

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1.0 Introduction

This service manual is for the MinXray model HF100H x-ray unit.
If you have any questions or need further assistance, please contact us. We are available Monday - Friday, 8:30 - 17:00 Central Time.

Service Department
MinXray, Inc.
3611 Commercial Avenue
Northbrook, Illinois 60062-1822
U.S.A.
Tel: 1-847-564-0323
Toll free tel: 1-800-221-2245 (U.S. and Canada)
Fax: 1-847-564-9040
E-mail: service @ minxray.com
Internet: www.minxray.com

⚠ Always connect the power cord to a grounded AC mains electrical outlet.

⚡ High voltage is present in some internal components.

☢ X-radiation is emitted during some calibration tests described within this manual. Observe radiation safety precautions when conducting these tests.

CARELESS OR IMPROPER USE OF X-RAY EQUIPMENT CAN BE EXTREMELY HAZARDOUS. It is imperative that this equipment be operated and serviced only by trained personnel familiar with the safety precautions required to prevent excessive exposure to primary and secondary radiation, the dangers of exposure to x-radiation, and the proper use of the equipment and instrumentation discussed in this manual. All personnel authorized to operate or service this equipment should be fully acquainted with the established maximum permissible doses, safety recommendations and procedures for working with high voltage components, and testing and calibration instrumentation.

Although this x-ray unit incorporates protective design features for limiting both the direct (primary) x-ray beam and the secondary radiation produced by this beam, design factors alone cannot prevent human carelessness, negligence, or lack of knowledge. This apparatus is sold with the understanding that the user assumes sole responsibility for radiation and electrical safety, and that MinXray, Inc., its agent and representatives, do not accept any responsibility for:

1. Injury or danger to patient or other personnel from x-ray exposure or electrical shock.
2. Overexposure due to poor operating techniques or procedures.
3. Equipment not properly serviced, installed, or maintained in accordance with operation and service manuals.
4. Equipment which has been modified or tampered with in any way.

2.0 DEVICE HISTORY

Item No.	Contents	Start S/No.
1	Pre- production	19716
2	Solder Lead on the insert	21192
3	Making 8 screws lock tighter for out case	21545
4	Fixing the nut of PCB M9110 by bond (KE42)	23232
5	Using PCB M3107-B	23232
6	Adding the label Dangerous Voltage & Ionizing Radiation	23232
7	Adding the fixing metal for insert	23539
8	Adding the fixing metal for collimator	23539
9	Changed the insert for balance collimator (D-180HS-G)	25150

NOTE : The parts list is used from MinXray HF100H (S/No. 25150)

3.0 SPECIFICATIONS

POWER :

Range -- 100 • •130VAC, 200 • •260VAC
Minimum voltage with no load --------- 100VAC, 200VAC
Maximum voltage with no load -------- 140VAC, 280VAC
Frequency ------------------------------------ 50/60Hz
Electricity consumption ------------ ------

	Minimum	Maximum
110V	16A(40kV)	30A(100kV)
220V	8A(40kV)	15A(100kV)

Maximum voltage consumption -------- 3.5kVA • 10%

NOTE : This unit would be severely damaged if it is used with incorrect line voltage. Check the rating label on the HF100H for the correct input voltage for each unit.

OUTPUT :

Inverter : 120kHz high frequency inverter system with neutral ground circuit, 2kW • 60kHz inverter.
tube potential feedback system
tolerance • 10%

Filament circuit : 0.5 Watt • 45kHz inverter
tube current feedback system
tolerance • 10%
pre-heat time : approximately 2sec.

WARM UP TIME : Approximately 10 seconds after each exposure and after the initial Power-on.

X-RAY OUTPUT :

Maximum tube voltage : 100kV • 10• •
Minimum tube voltage : 40kV • 10%
kV switch : 2kV steps
Tube current : 20mA constant • 10%
Timer range : 0.08 – 4.00 sec. 0.01 sec. steps
Tolerance • 10%

X-RAY TUBE :

TOSHIBA D-124S
focal spot size : 1.2mm• 1.2mm
target material : tungsten
angle : 16• •
anode heat storage capacity : 14kJ (20.0kHU)

COLLIMATOR :

Collimax model D-180HS-G
Continuously adjustable light beam type with central ray indicator, and cassette size/distance indicator to aid in correct positioning.

On time :	30 sec.
Bulb :	Philips No.6550 15V150W
Blub life :	longer than 50 hours
Illuminance :	over 160 lux at 1 m SID
Contrast ratio :	over 3:1 at 1 m SID

NOTE: Please refer to Collimator Operator's and installer's manual (Page 20)

FILTRATION :	inherent filtration	2.2mm Al
	collimator filtration	1.2mm Al
	total filtration	3.4mm Al
WEIGHT :	20kgs	
SIZE :	29 cm (W) • •23.8 cm (H) • •45.5 cm (L)	
POWER CORD :	3.6 m	
EXPOSURE SWITCH :	two stage, 3.0 m	

4.0 OPERATING PROCEDURES

CONNECTION : After confirming POWER CORD and EXPOSURE SWITCH are intact, securely connect them to main body of x-ray unit.
(If connector has lock, confirm it is locked.)
Confirm POWER SWITCH is OFF and connect POWER CORD to wall outlet or wall socket of proper mains.
(When you use an extension cord, 3.5kW should be obtained.)

POWER ON : Set POWER SWITCH on control panel to ON. Each indicator will illuminate. When the unit is warming up (WARM UP indicator is lit), exposures can not be taken. After approx. 10 sec.,
WARM UP indicator will go off. The unit is now ready to use.

DO NOT SWITCH ON AND OFF QUICKLY IN A SHORT TIME. WHEN TURNING ON AGAIN AFTER TURNING OFF, WAIT FOR AT LEAST 1 MINUTE. OTHERWISE, THE HIGH FREQUENCY INVERTER CANNOT WORK PROPERLY.

kV SETTING : Set kV in the range of 40kV to 100kV.

TIMER SETTING : Set timer in the range of 0.08 sec. to 4.00 sec. depending on subject, distance and screen/film combination. Time increments are 0.01 sec. per step.

SOURCE-IMAGE DISTANCE:
Use the tape measure on the side of the HF100H to confirm that the x-ray unit is positioned at the correct source-image distance (SID) for the view being taken.

ADJUSTMENT OF RADIATION FIELD :
Pressing the collimator switch will illuminate the field for approx. 30sec.
Adjust light field to position of radiograph by two knobs for adjustment of opening.
During this time, use the adjustment knobs to size the radiograph as you need.

RADIOGRAPHY :
Make sure that WARM UP indicator is OFF before pressing the exposure switch.

WARM UP INDICATOR TURNS OFF 10 SEC. AFTER POWER ON.
WARM UP INDICATOR TURNS OFF 10 SEC. AFTER EACH EXPOSURE.
IF WARM UP INDICATOR IS ON, X-RAY EXPOSURE IS IMPOSSIBLE.

Make sure all WARNING LAMPS are off.
After all safety checks, press only first stage of EXPOSURE SWITCH.
STANDBY indicator goes off after 1 sec. Then, unit is ready for exposure. Press and hold the second stage of EXPOSURE SWITCH. X-RAY indicator illuminates, the buzzer sounds, and x-ray is generated for the time set. The EXPOSURE SWITCH is a DEADMAN style. If the button is released, exposure is stopped. So, press and hold the button until exposure is complete.

WARM UP indicator will light after exposure.

⚠ **NOTE : The first stage of EXPOSURE SWITCH is pre-heat of filament.**
DON'T KEEP ONLY THE FIRST STAGE OF EXPOSURE SWITCH "ON" LONGER THAN 30 SEC.

POWER OFF : When the POWER SWITCH is pressed, all indicators on the control panel are off.

WARNING LAMP : HF100H has 2 kinds of warning lamps. If either of them is lit, x-ray cannot be generated. Each detail is as follows.

WARNING LAMP	DETAILS	COUNTERMEASURE
WARM UP	The internal circuit is warming up.	Wait until light goes off.
ERROR	Unit malfunction.	Stop procedure and follow steps below.

• ••If ERROR indicator is lit even when EXPOSURE SWITCH BUTTON is released, it means an unusual situation has occurred. Turn off POWER SWITCH, wait 3 minutes, then start procedures over again.

• ••This unit generates x-ray by an inverter. Therefore, it requires warm up time to be stable after power on and each exposure. When WARM UP indicator is off, warm up is finished.

5.0 Pre-adjustment (Refer to page 40, page 41)

• • Each PC Board delivered from the factory has already been adjusted.

1. 24VDC power supply adjustment (SVB24SA)

Check output (DCV) at Red (+) and Black (–) wires. Adjust VR on the SVB24SA to be C24V• • 0.3V.

2. M3108A adjustment (Refer to page 8)

kV adjustment : **kV is decreased by turning clockwise.**

1. This adjustment requires the special test equipment (HF Tester).
2. Check the DC voltage between the kV (+) and GND on the test equipment (HF Tester).
3. Set the kV selector to 100kV and turn VR1 so that the DC Voltage is 5.0V.
4. Check the voltage at each kV setting.
5. Finally check the kV by using an external kV tester such as the VICTOREEN NERO. The reading will indicate a little lower than the actual output because of the tester dynamics for high frequency x-ray production, so don't adjust over 99kV indicated by testing device.

mA adjustment : **mA is decreased by turning clockwise.**

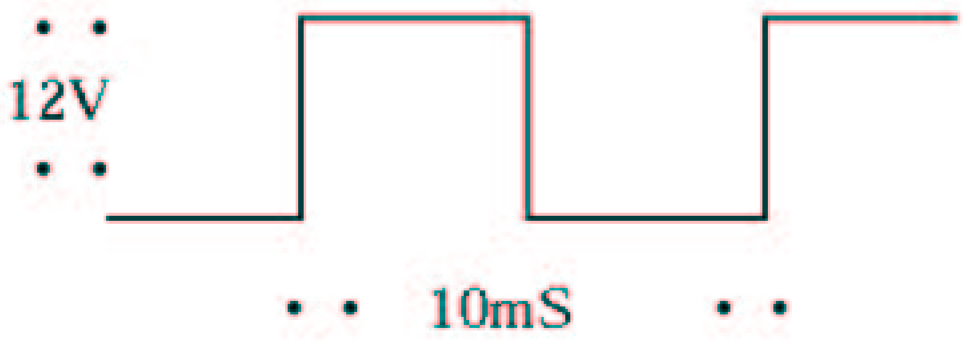
1. This adjustment requires the special test equipment (HF Tester).
2. Check the DC voltage between the mA (+) and GND on the test equipment (HF Tester)..
3. Confirm the mA indicator to be 20mA and turn VR5 so that the DC Voltage is 2.0V.

Exposure time adjustment : **Exposure time is decreased by turning clockwise.**

Time base is 100Hz (10msec.). When jumper of JP2 is pulled out, X-RAY LED is lit without relating to timer. Measure voltage between TIME test point and GND test point by Oscilloscope, and adjust by VR6.

IMPORTANT : Disconnect the connector JP2 on M3108A PCB before removing the jumper of X-RAY. Otherwise, Inverter PC Board will work and X-RAY will be generated unrelated to timer setting and X-RAY unit might be damaged.

• •Pull in and pull out connectors only with MAIN POWER OFF.

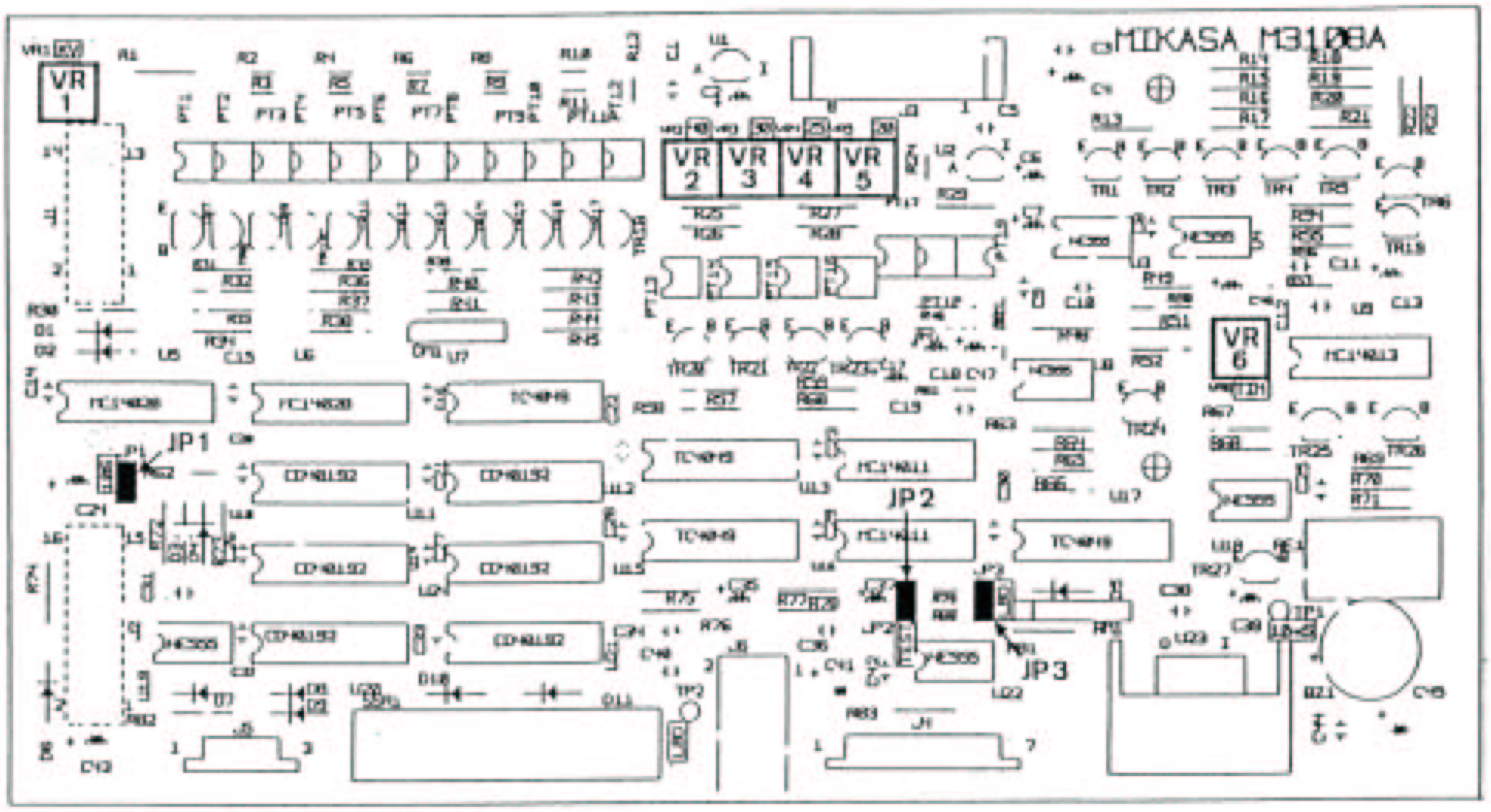


• TIME BASE WAVEFORM

NOTE : Please contact MinXray, Inc. (Service Department) if you need information of the special test equipment (HF Tester).

REFFERENCE : There are three jumpers on M3108A (10SEC ,TEST and LBD)

10SEC :	When jumper is put in, WARM UP time is 1 sec. DO NOT USE. When jumper is pulled out, it is 10 sec. This jumper is for adjustment at the factory before shipment. So, please don't use the device with jumper.
TEST :	**• NEVER PULL OUT THIS SHORT PIN. X-RAY WILL BE GENERATED PERMANENTLY AND DANGEROUSLY.**
LBD:	Not used



3. M9111 PC Board adjustment (refer to page 9)

It can adjust the following:

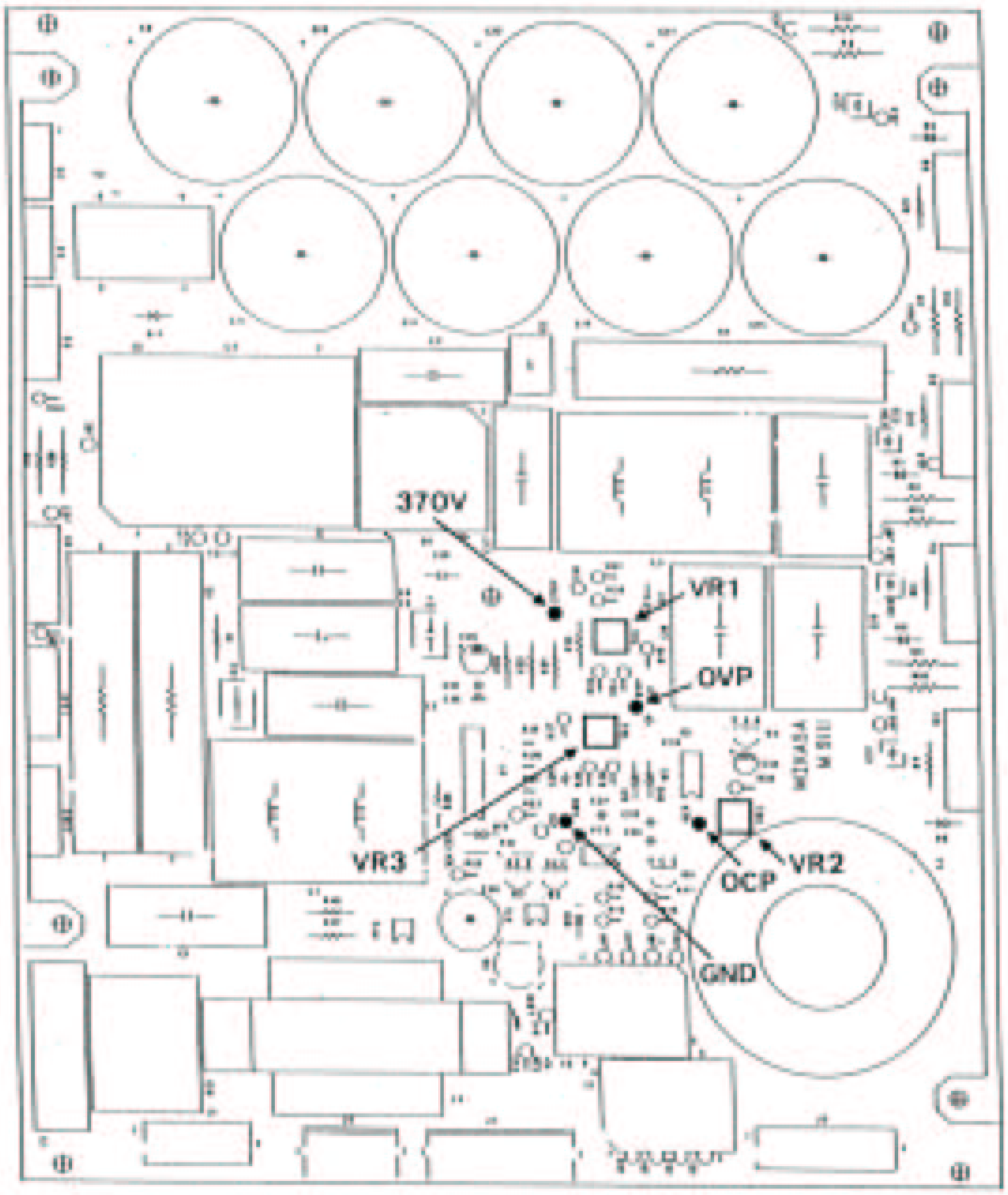
- Over Voltage Protection circuit (VR1)
- Over Current Protection circuit (VR2)
- DC voltage adjust circuit (VR3)
  Calibrated DC voltmeter is necessary.

4. M9112 PC Board adjustment (refer to page 10)

It can adjust the following:

- Frequency of Inverter PC Board (VR1)
- Pre-heat time for Low mode (VR3)
- kV (VR4)
- mA (VR5)

M9111 PC Board adjustment



This adjustment has to be done after connecting all connectors completely. Actual x-ray exposure is not necessary.

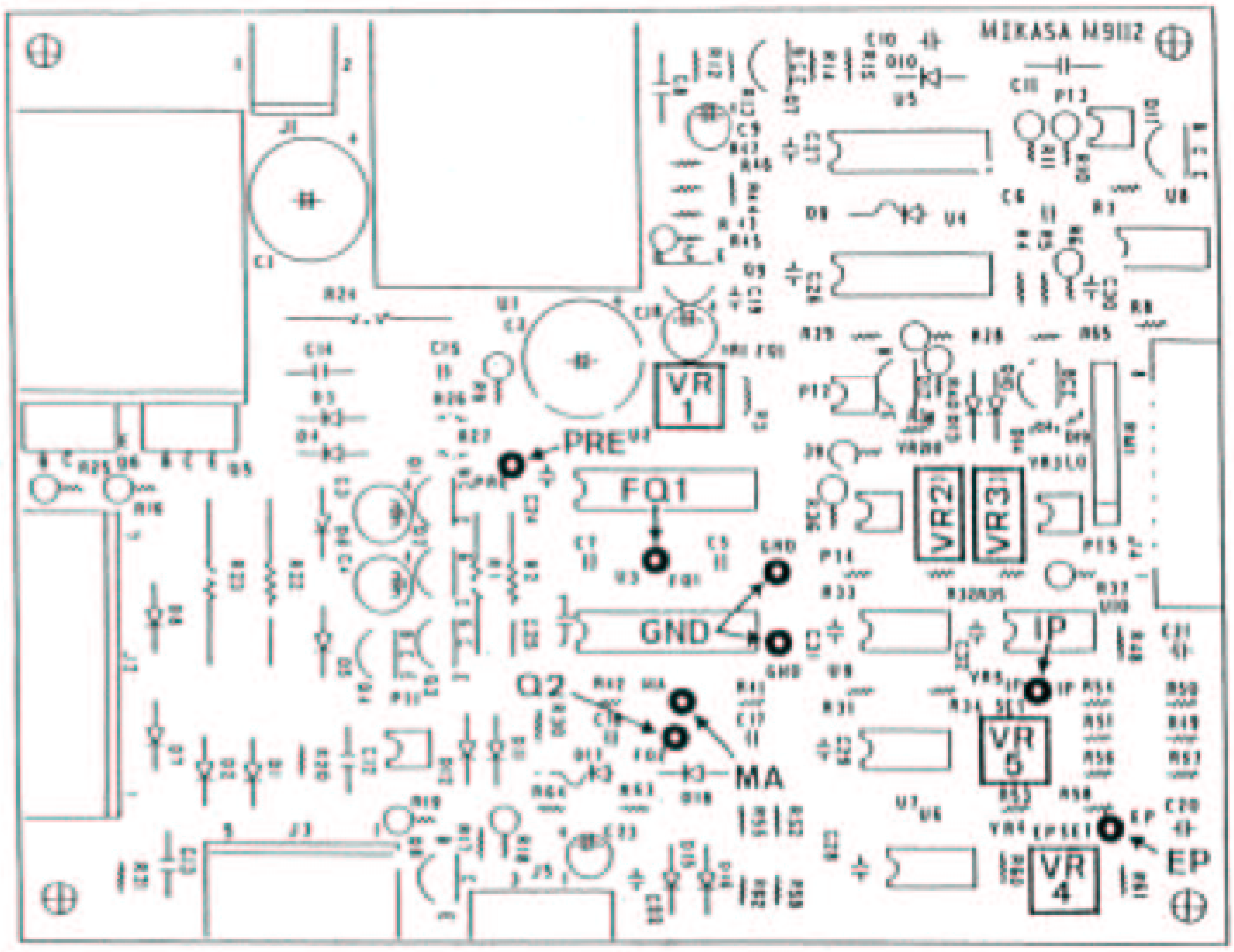
- Each PC Board delivered from the factory has been already adjusted.

1. Adjustment of VR3 (DC370V)
   Adjust voltage between 370 (+) and GND (–) to be 368.5 – 372V by turning VR3.
   Voltage is increased by turning clockwise.

2. Adjustment of VR2 (Over Current Protection circuit)
   Adjust voltage between OCP(+) and GND (–) to be 1.09 – 1.11V by turning VR2.
   Voltage is increased by turning clockwise.

3. Adjustment of VR1 (Over Voltage Protection circuit)
   Adjust voltage between OVP (+) and GND (–) to be 2.4 – 2.45V by turning VR1.
   Voltage is decreased by turning clockwise.

M9112 PC Board adjustment



This adjustment has to be done after connecting all connectors completely. Actual x-ray exposure is not necessary.

- Each PC Board delivered from the factory has been already adjusted.

1. Adjustment of FQ1
   Adjust frequency between FQ1 (+) and GND (–) to be 120kHz by turning VR1.
   Frequency is increased by turning clockwise.

2. Confirmation of FQ2
   Confirm if frequency between FQ2 (+) and GND (–) is 90kHz • 5%. It cannot be adjusted.

3. Adjustment of Pre-heat voltage at 20mA.
   Adjust voltage between PRE (+) and GND (–) to be 0.43V by turning VR3.
   Voltage is increased by turning clockwise.

4. Set VR4 (EP SET) to the center position.

5. Set VR5 (IP SET) to the center position.

6.0 Re-adjustment of kV

This adjustment has to be done after connecting all connectors completely. Actual exposure is necessary.

NOTE : This adjustment requires that an exposure be made. Please observe all radiation related safety precautions.

- This adjustment should be done whenever Insert Box or Inverter PC Board (M9101B PCB) is replaced.

Oscilloscope (with storage mode) : Connect CH1 probe to EP, CH2 probe to IP, and GND to GND terminal on M9112 PC Board. (refer page 9)

Setting of oscilloscope : CH1 ; 1V/div, CH2 ; 0.5V/div, 10msec/div

Setting of x-ray device : 0.1 sec., 70kV

Place of adjustment : VR4 on M9112 PC Board (EP SET)

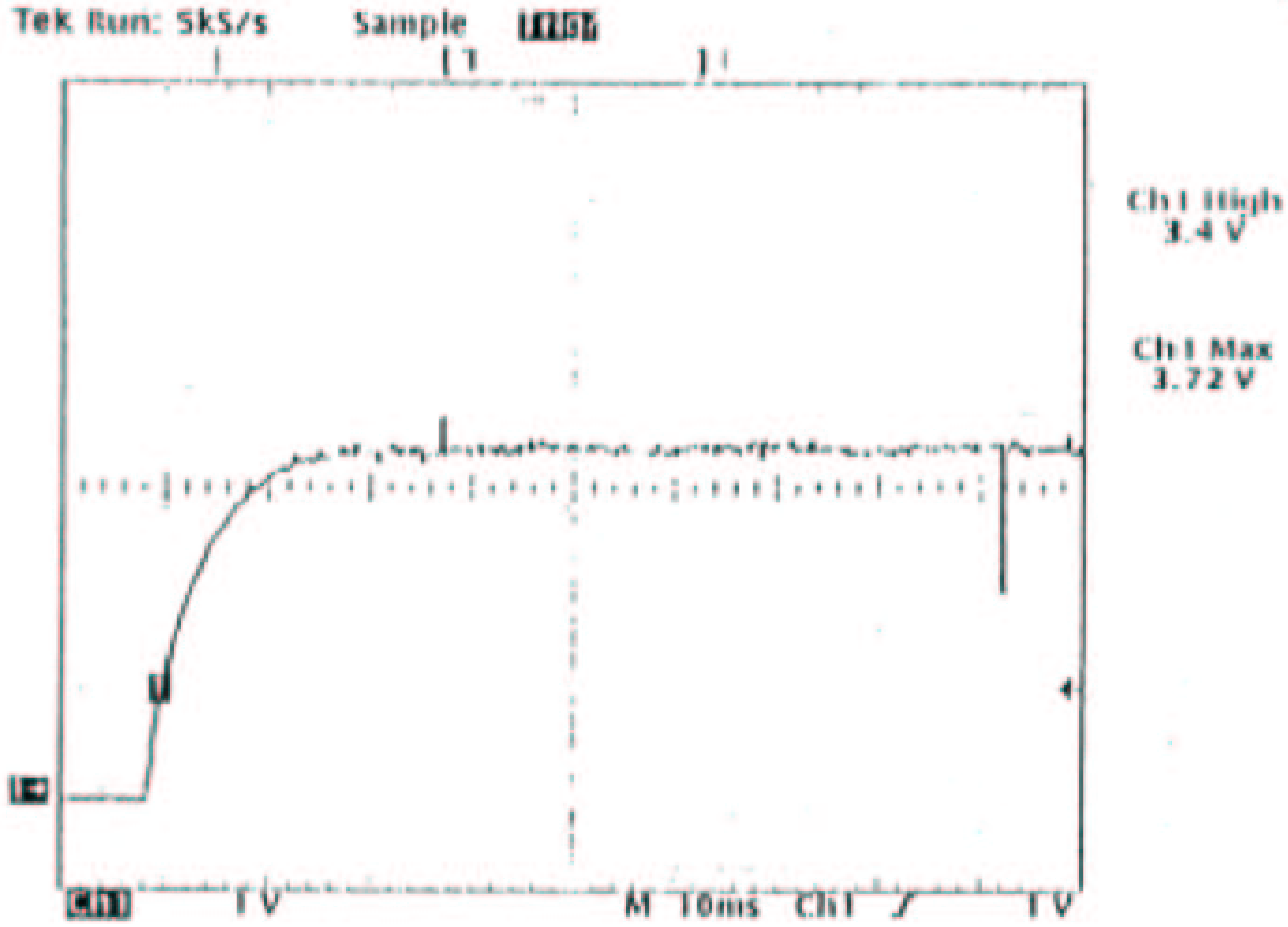
Method of adjustment : Measure x-ray tube voltage by oscilloscope and adjust average of peak values of EP waveform to be 3.4V by VR4.
After the adjustment is finished, set of device to be 100kV and adjust again so that average of peak values of EP waveform to be 4.9V.

When x-ray tube voltage is measured by non invasive direct x-ray measuring equipment such as NERO, approx. 3kV of deviation is included. Therefore, adjust kV to be 97.5 • •99kV at 100kV station.

5 – 1. Adjustment of 70kV by VR4

Adjust the ch1 (Ep) by VR4 to be 3.4V • 0.5V.

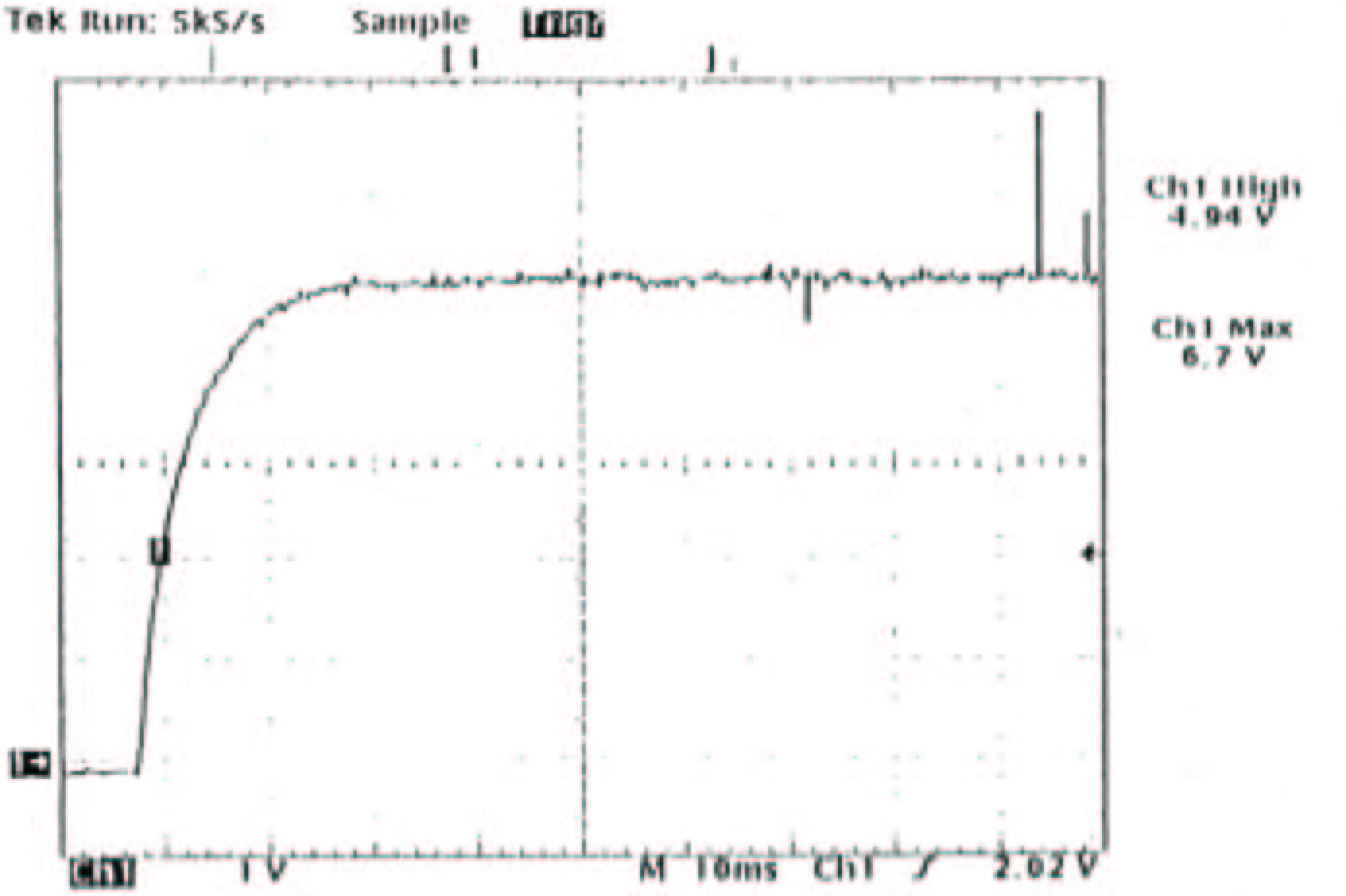
kV is increased by turning clockwise.



5 – 2. Adjustment of 100kV by VR4

Adjust the ch1 (Ep) by VR4 to be 4.9V • 0.5V.

kV is increased by turning clockwise.



7. 0 Re-adjustment of Pre-heat and mA

⚠ ☢ **This adjustment has to be done after connecting all connectors completely.
Actual exposure is necessary.**

NOTE : This adjustment requires that an exposure be made. Please observe all radiation related safety precautions.

*This adjustment should be done whenever Insert Box or Inverter PC Board (M9112 PCB) is replaced.

Oscilloscope (with storage mode) : Connect CH1 probe to EP, CH2 probe to IP, and GND to GND terminal on M9112 PC Board. (refer page 9)

Setting of oscilloscope : CH1 ; 1V/div, CH2 ; 1V/div, 10msec/div

Setting of x-ray device : 0.1 sec., 80kV

Place of adjustment : VR3 (Pre-heat voltage) • VR5(mA)

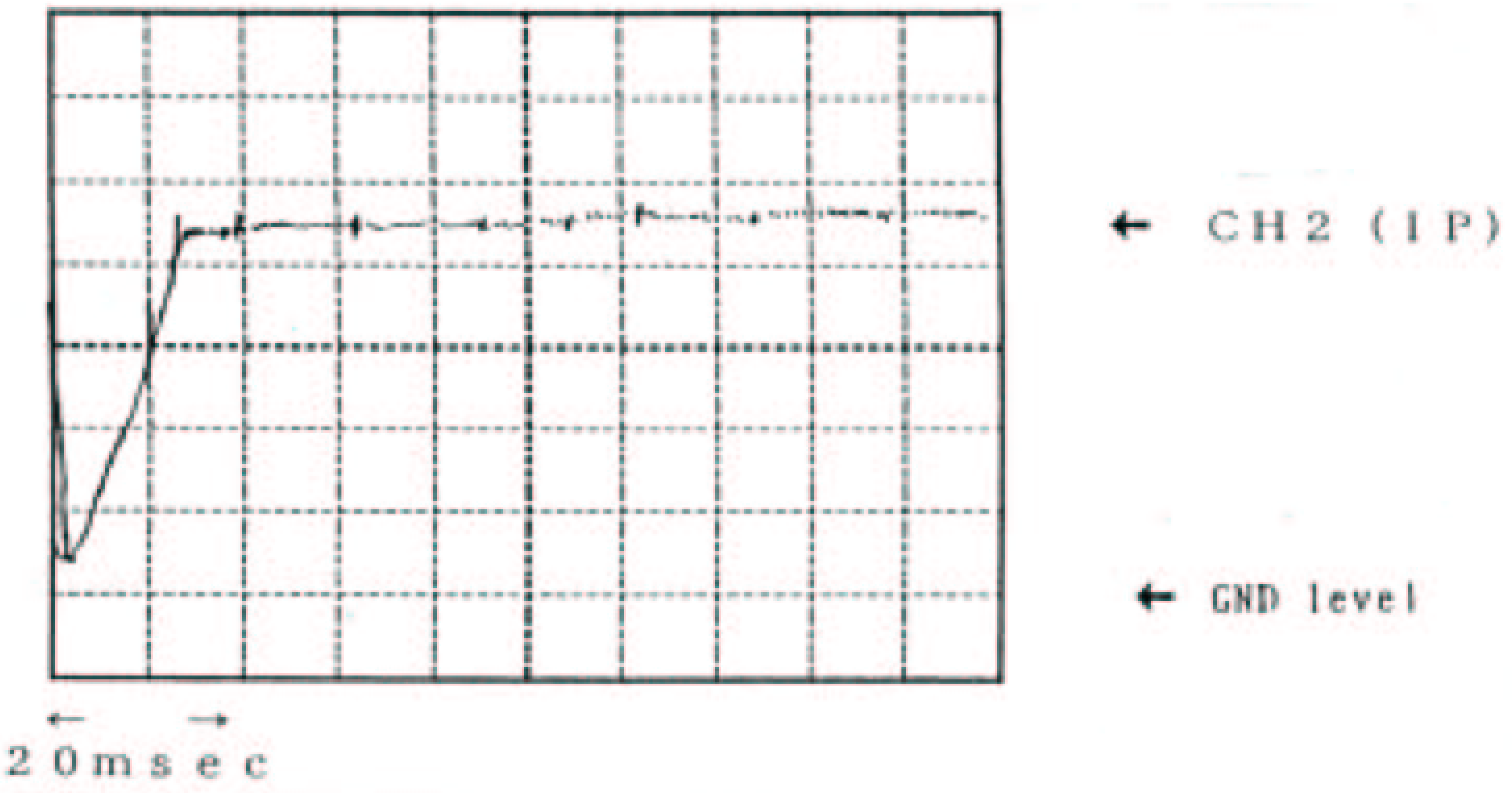
VR3 : adjustment of Pre-heat time at 25• 20mA.
(Pre-heat time is shorten by turning clockwise.)

VR5 : set 20mA and adjust to be 19mA

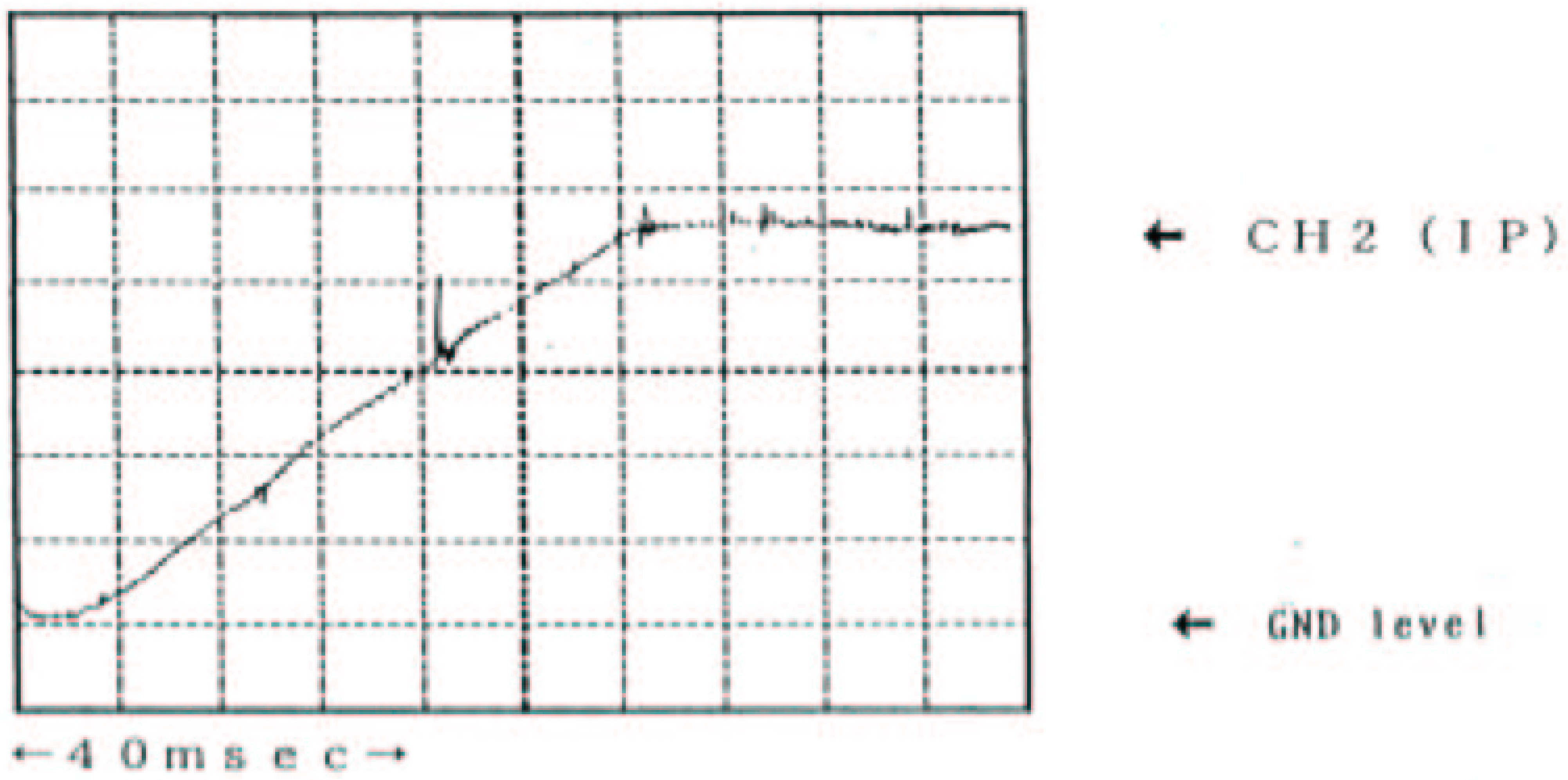
- Pre-heat time should be adjusted to be 30msec.• 10msec.

6 –1. Adjustment of Pre-heat time

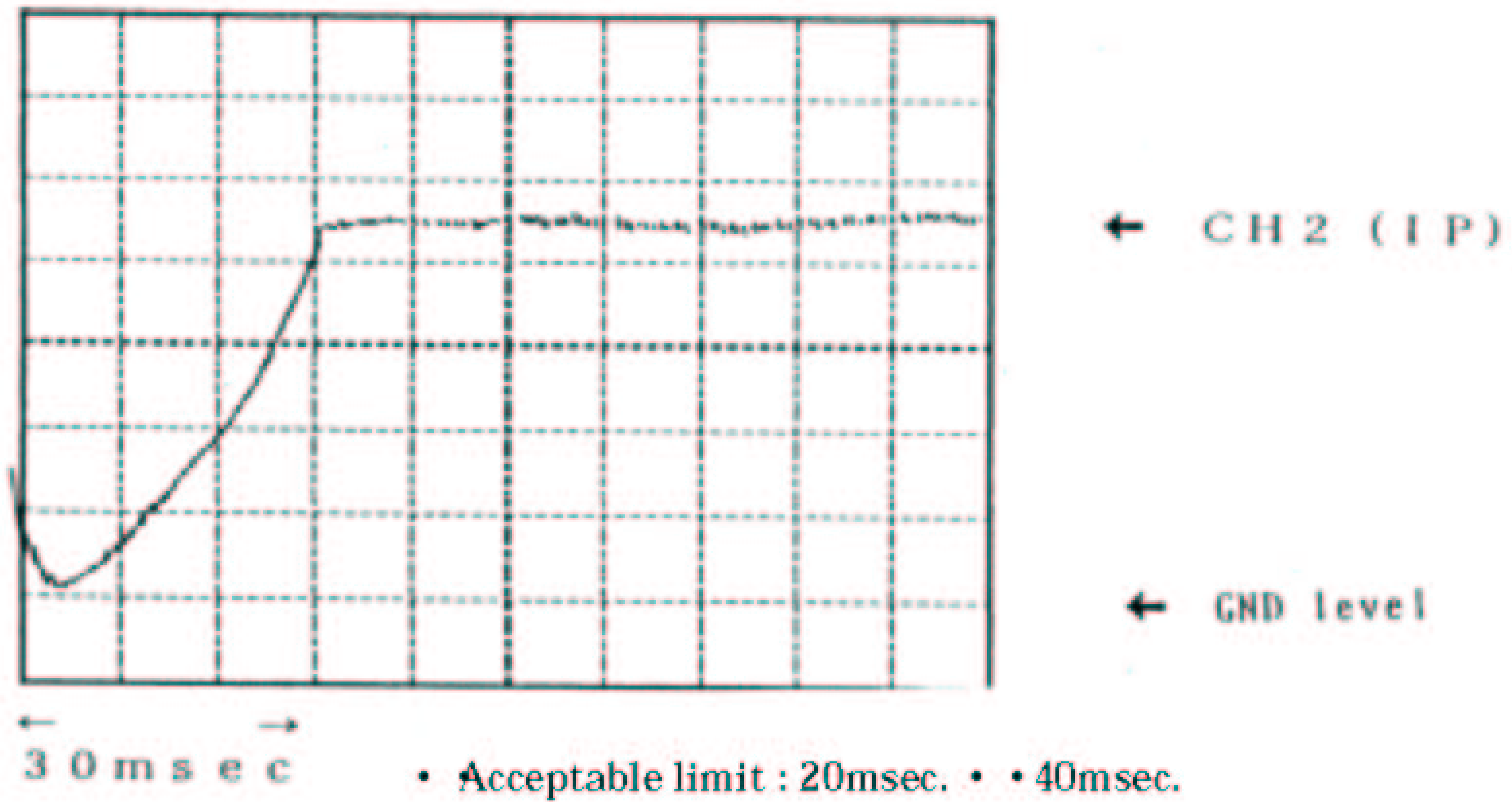
1. Pre-heat time is short. Make Pre-heat time longer by turning VR3 counterclockwise.



2. Pre-heat time is long. Make Pre-heat time shorter by turning VR3 clockwise.



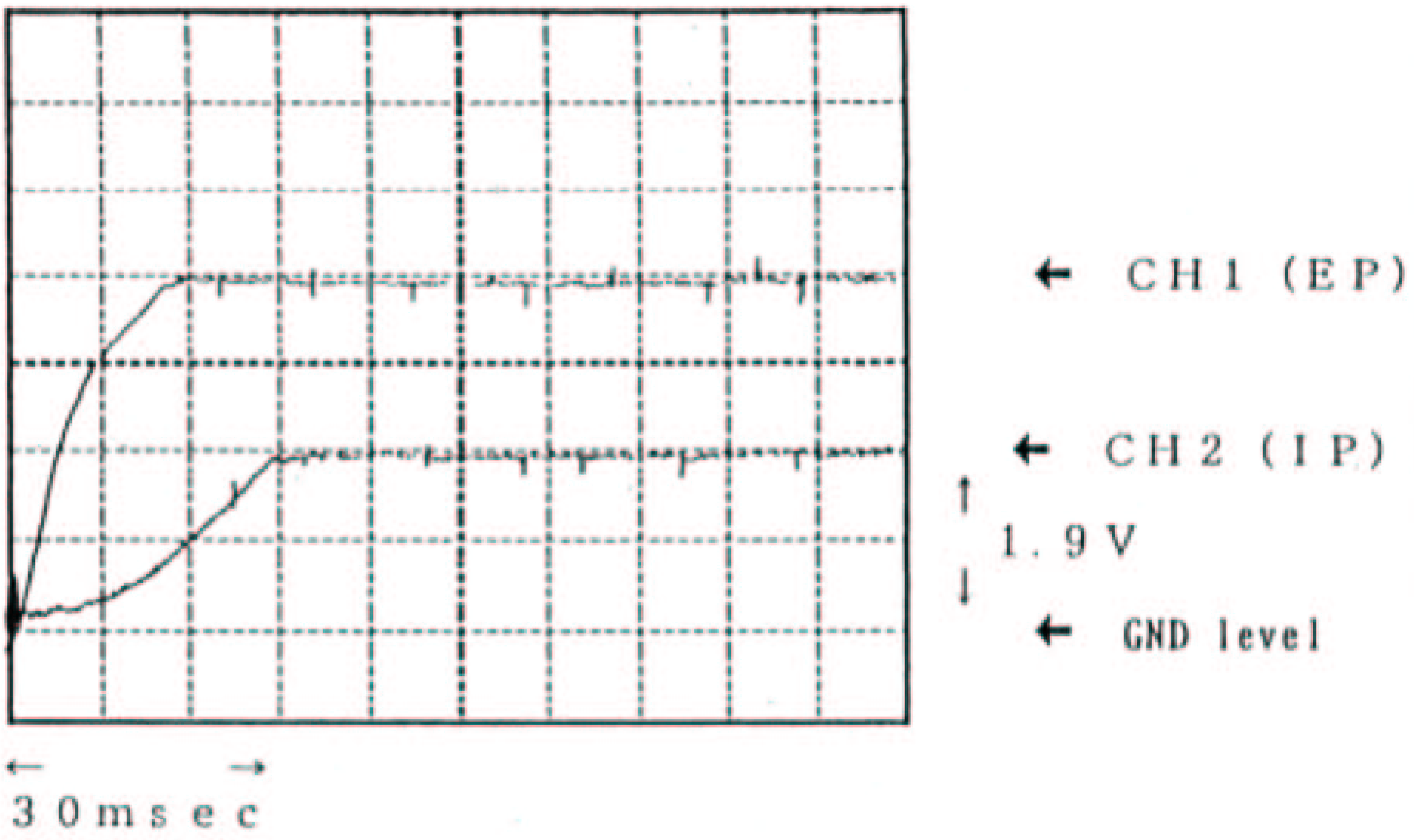
3. Pre-heat time is appropriate.



• Acceptable limit : 20msec. • • 40msec.

6 -2 – 1. Adjustment of mA by VR5

- Adjust average of peak values of IP waveform to be 1.9V by VR5.



8.0 Readjustment of exposure time

⚠ ☢ **This adjustment has to be done after connecting all connectors completely. Actual exposure is necessary.**

NOTE: This adjustment requires that an exposure be made. Please observe all radiation related safety precautions.

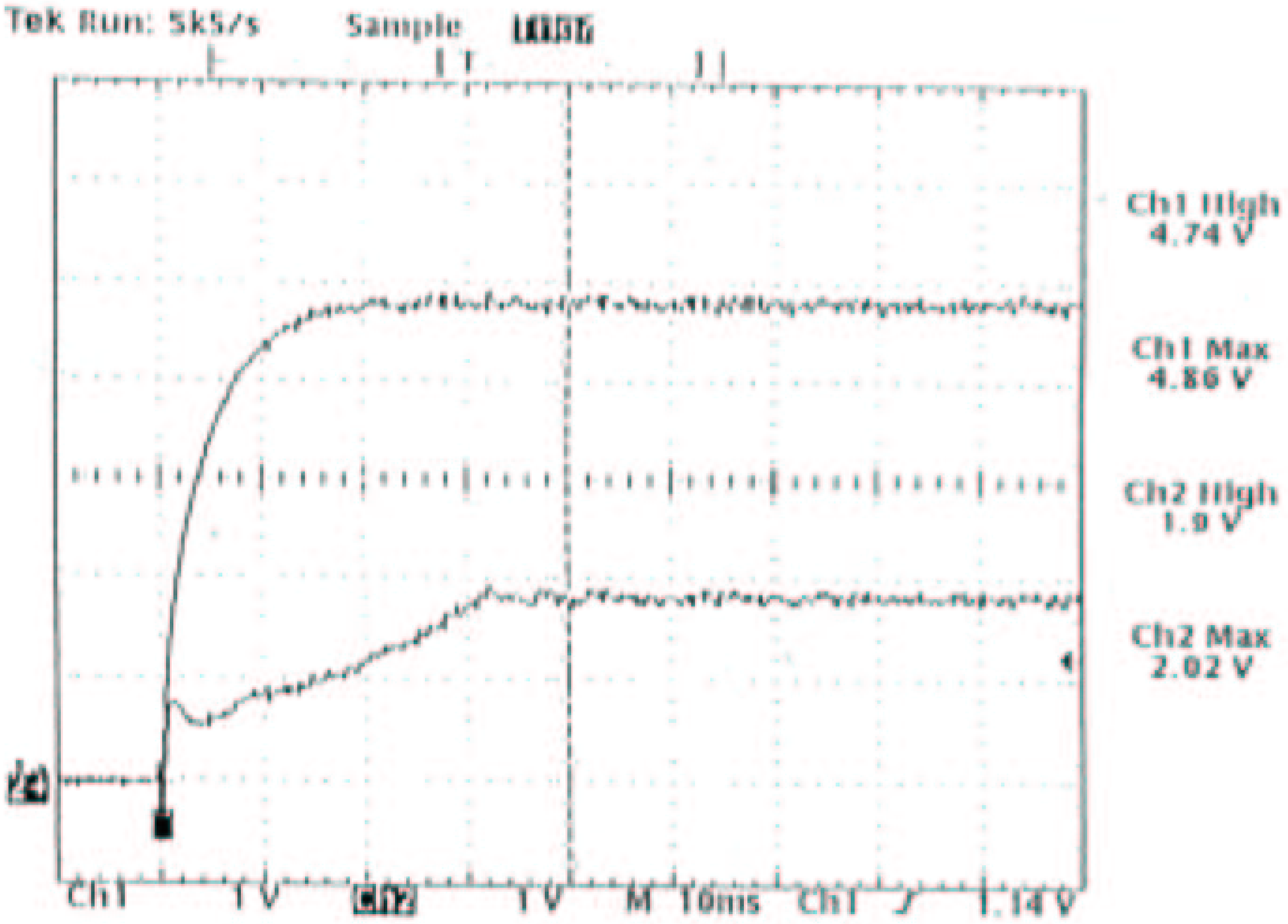
Check the exposure time by using an external exposure time meter such as the VICTOREEN NERO.

X-ray unit setting: 82kV • • 0.5sec
Adjustment: Exposure time is decreased by turning clockwise. (VR6 on the M3108A PC board)

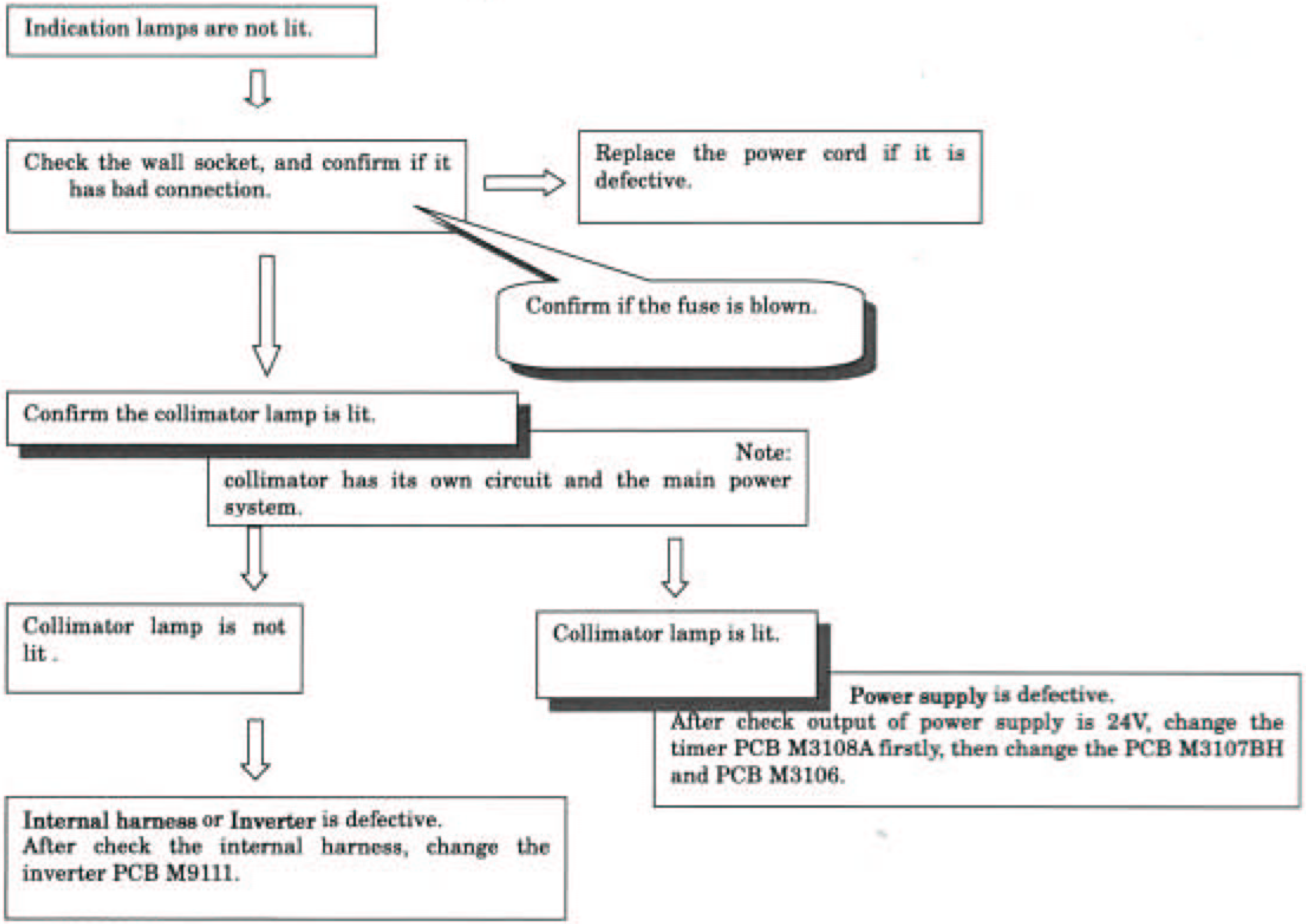
9.0 Sample of output waveform

Normal waveform

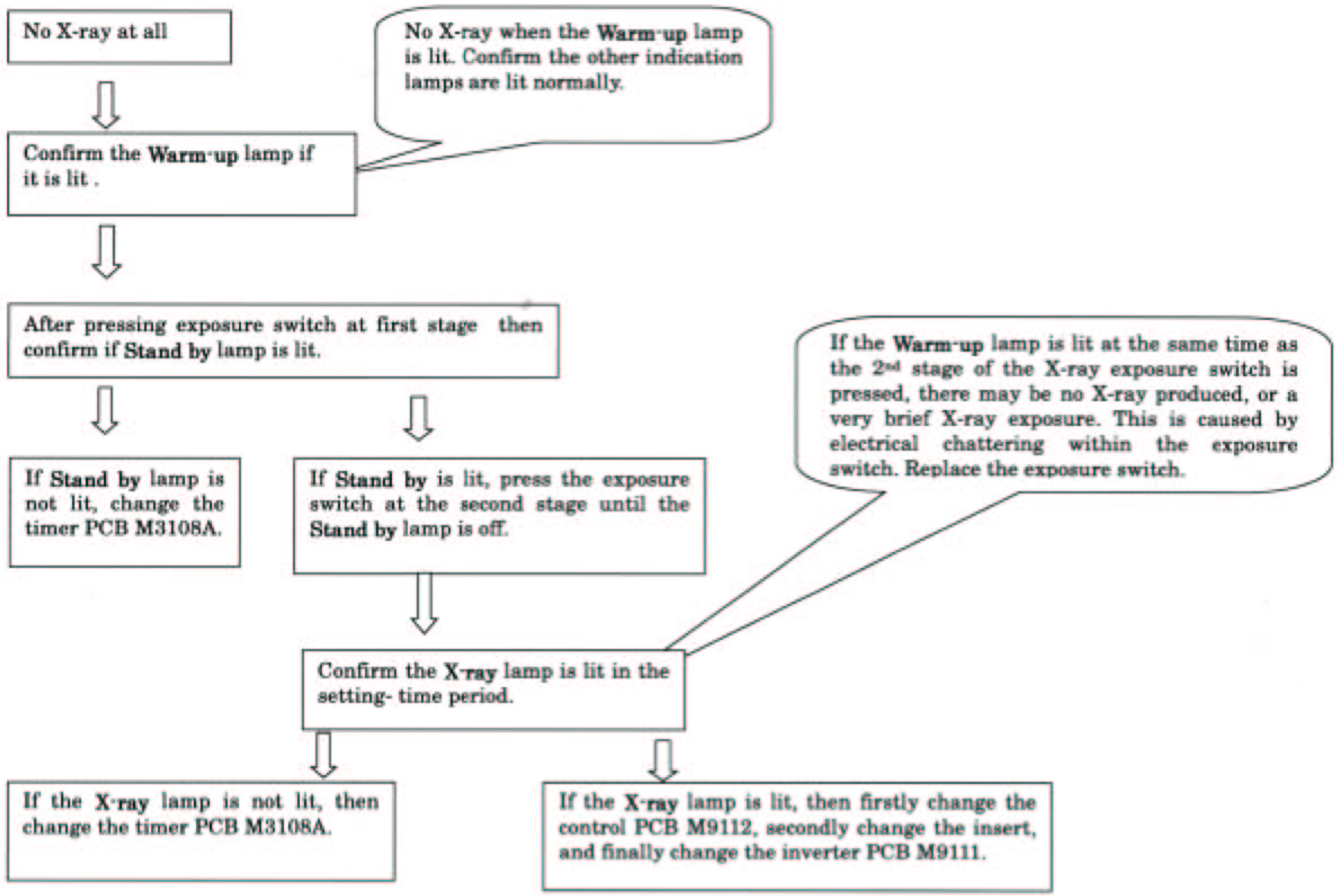
100kV • ••20mA



1. INDICATED LAMPS ARE NOT LIT WHEN POWER SWITCH IS AT "ON" POSITION


Indication lamps are not lit.
Check the wall socket, and confirm if it has bad connection.
Replace the power cord if it is defective.
Confirm if the fuse is blown.
Confirm the collimator lamp is lit.
Note: collimator has its own circuit and the main power system.
Collimator lamp is not lit .
Collimator lamp is lit.
Internal harness or Inverter is defective.
After check the internal harness, change the inverter PCB M9111.
Power supply is defective.
After check output of power supply is 24V, change the timer PCB M3108A firstly, then change the PCB M3107BH and PCB M3106.

2. NO X-RAY AND ERROR LAMP IS NOT LIT



No X-ray at all

Confirm the **Warm-up** lamp if it is lit .

No X-ray when the **Warm-up** lamp is lit. Confirm the other indication lamps are lit normally.

After pressing exposure switch at first stage then confirm if **Stand by** lamp is lit.

If **Stand by** lamp is not lit, change the timer PCB M3108A.

If **Stand by** is lit, press the exposure switch at the second stage until the **Stand by** lamp is off.

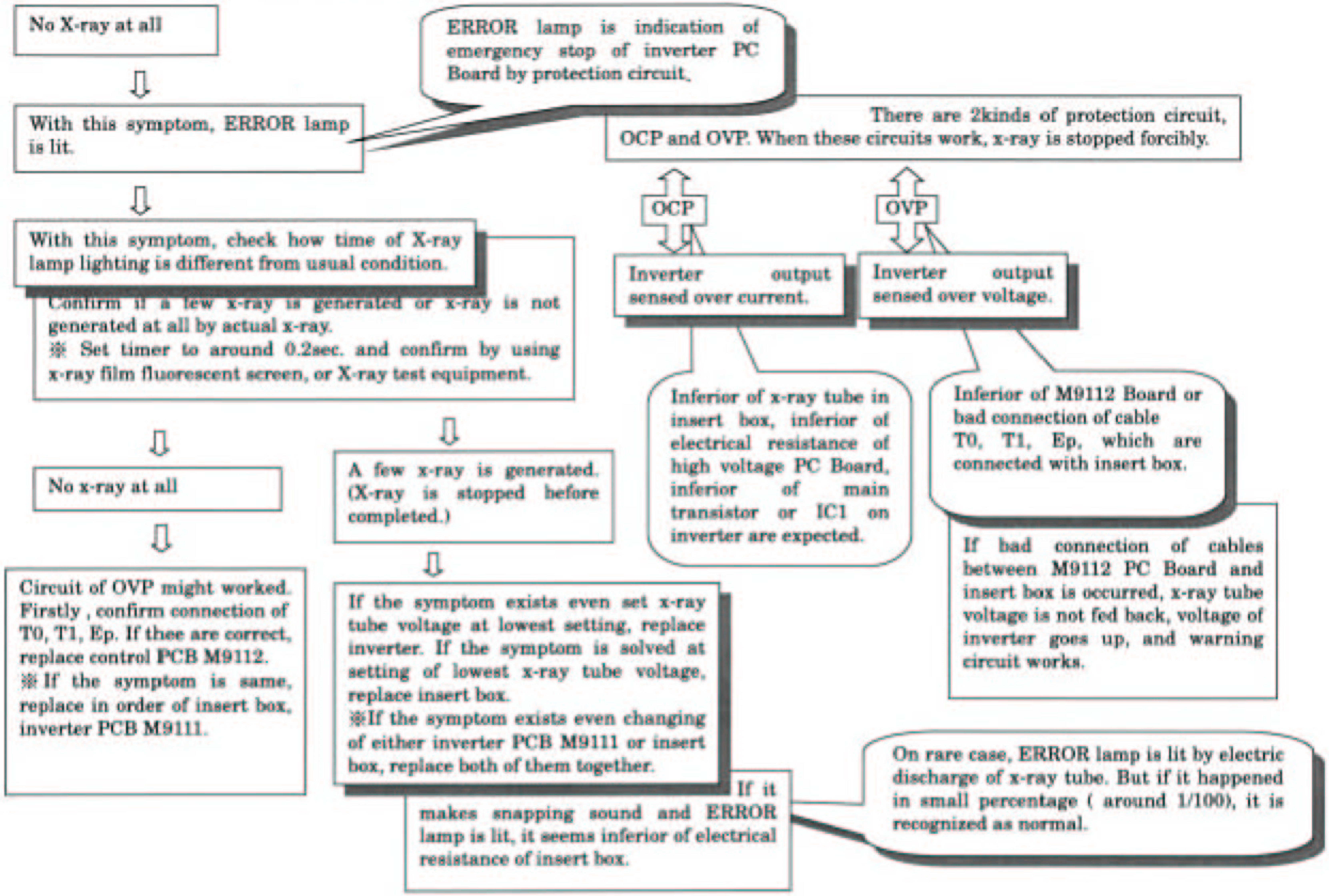
If the **Warm-up** lamp is lit at the same time as the 2nd stage of the X-ray exposure switch is pressed, there may be no X-ray produced, or a very brief X-ray exposure. This is caused by electrical chattering within the exposure switch. Replace the exposure switch.

Confirm the **X-ray** lamp is lit in the setting- time period.

If the **X-ray** lamp is not lit, then change the timer PCB M3108A.

If the **X-ray** lamp is lit, then firstly change the control PCB M9112, secondly change the insert, and finally change the inverter PCB M9111.

3. ERROR LAMP IS LIT AND NO X-RAY



No X-ray at all

With this symptom, ERROR lamp is lit.

ERROR lamp is indication of emergency stop of inverter PC Board by protection circuit.

There are 2kinds of protection circuit, OCP and OVP. When these circuits work, x-ray is stopped forcibly.

With this symptom, check how time of X-ray lamp lighting is different from usual condition.

Confirm if a few x-ray is generated or x-ray is not generated at all by actual x-ray.
※ Set timer to around 0.2sec. and confirm by using x-ray film fluorescent screen, or X-ray test equipment.

No x-ray at all

Circuit of OVP might worked. Firstly , confirm connection of T0, T1, Ep. If thee are correct, replace control PCB M9112.
※If the symptom is same, replace in order of insert box, inverter PCB M9111.

A few x-ray is generated. (X-ray is stopped before completed.)

If the symptom exists even set x-ray tube voltage at lowest setting, replace inverter. If the symptom is solved at setting of lowest x-ray tube voltage, replace insert box.
※If the symptom exists even changing of either inverter PCB M9111 or insert box, replace both of them together.

If it makes snapping sound and ERROR lamp is lit, it seems inferior of electrical resistance of insert box.

On rare case, ERROR lamp is lit by electric discharge of x-ray tube. But if it happened in small percentage (around 1/100), it is recognized as normal.

Inverter output sensed over current.

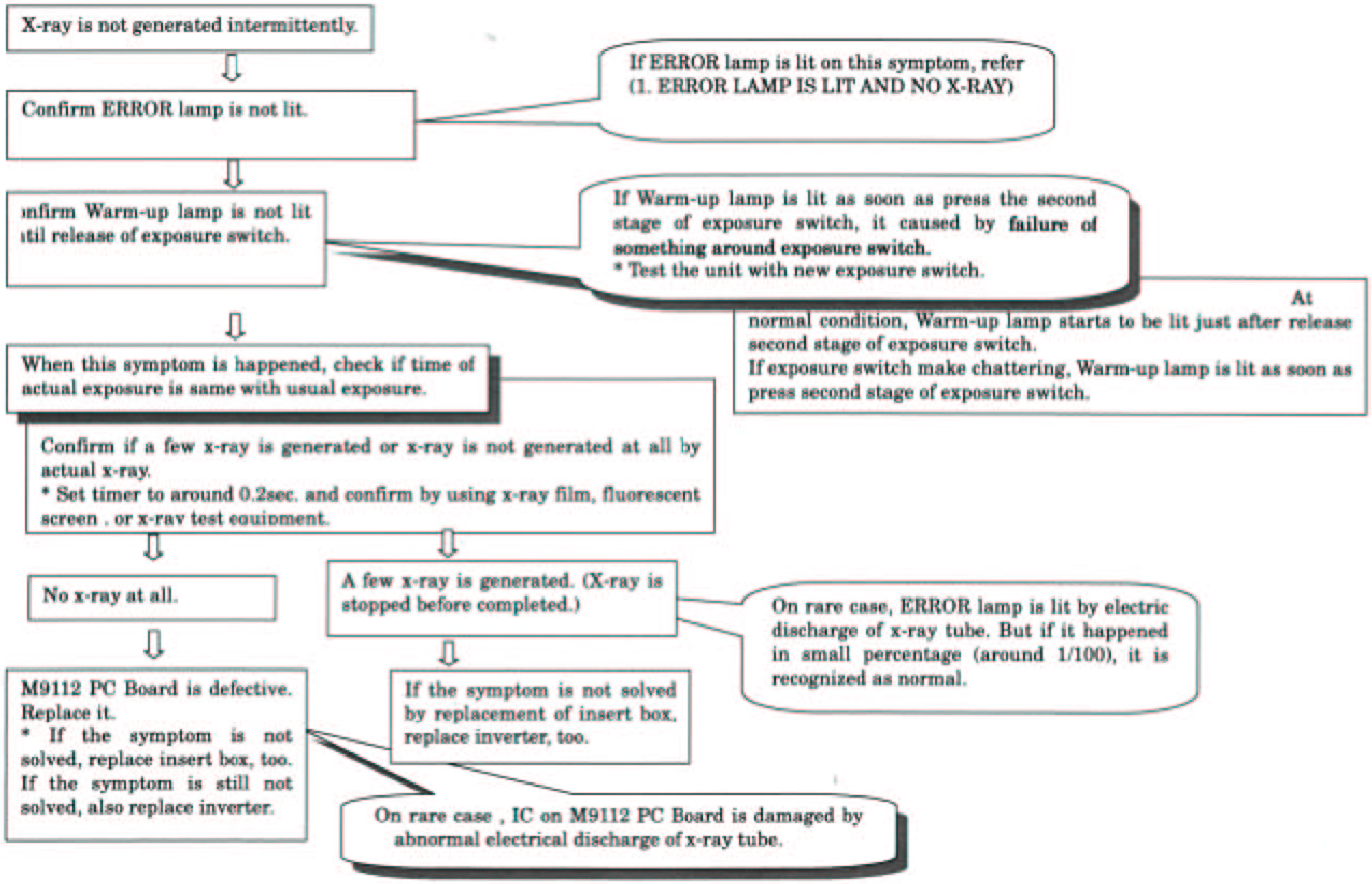
Inferior of x-ray tube in insert box, inferior of electrical resistance of high voltage PC Board, inferior of main transistor or IC1 on inverter are expected.

Inverter output sensed over voltage.

Inferior of M9112 Board or bad connection of cable T0, T1, Ep, which are connected with insert box.

If bad connection of cables between M9112 PC Board and insert box is occurred, x-ray tube voltage is not fed back, voltage of inverter goes up, and warning circuit works.

4. X-RAY IS NOT GENERATED INTERMITTENTLY



X-ray is not generated intermittently.

Confirm ERROR lamp is not lit.

If ERROR lamp is lit on this symptom, refer (1. ERROR LAMP IS LIT AND NO X-RAY)

nfirm Warm-up lamp is not lit til release of exposure switch.

If Warm-up lamp is lit as soon as press the second stage of exposure switch, it caused by **failure of something around exposure switch.**
* Test the unit with new exposure switch.

At normal condition, Warm-up lamp starts to be lit just after release second stage of exposure switch.
If exposure switch make chattering, Warm-up lamp is lit as soon as press second stage of exposure switch.

When this symptom is happened, check if time of actual exposure is same with usual exposure.

Confirm if a few x-ray is generated or x-ray is not generated at all by actual x-ray.
* Set timer to around 0.2sec. and confirm by using x-ray film, fluorescent screen . or x-rav test eauipment.

No x-ray at all.

M9112 PC Board is defective. Replace it.
* If the symptom is not solved, replace insert box, too. If the symptom is still not solved, also replace inverter.

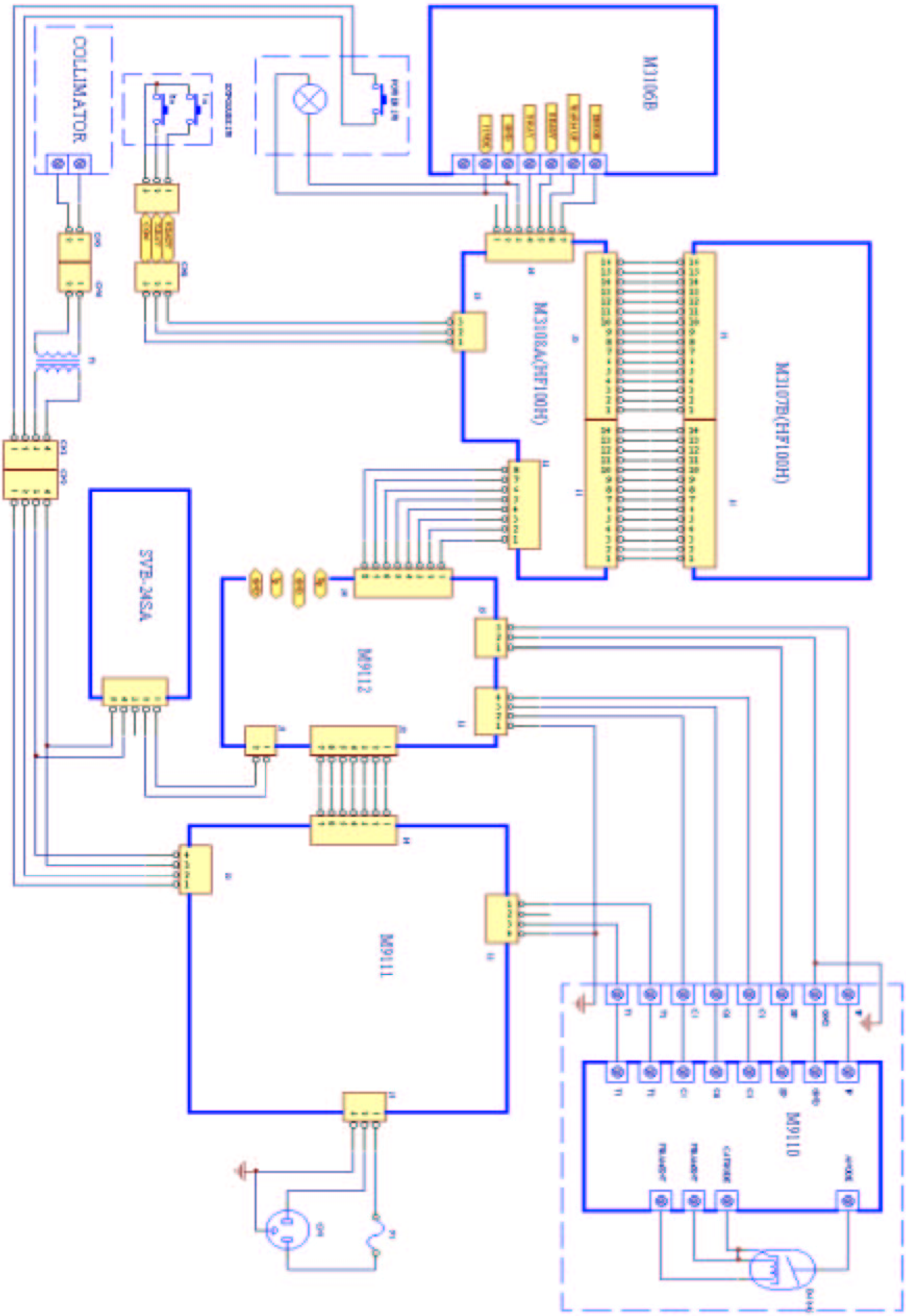
A few x-ray is generated. (X-ray is stopped before completed.)

On rare case, ERROR lamp is lit by electric discharge of x-ray tube. But if it happened in small percentage (around 1/100), it is recognized as normal.

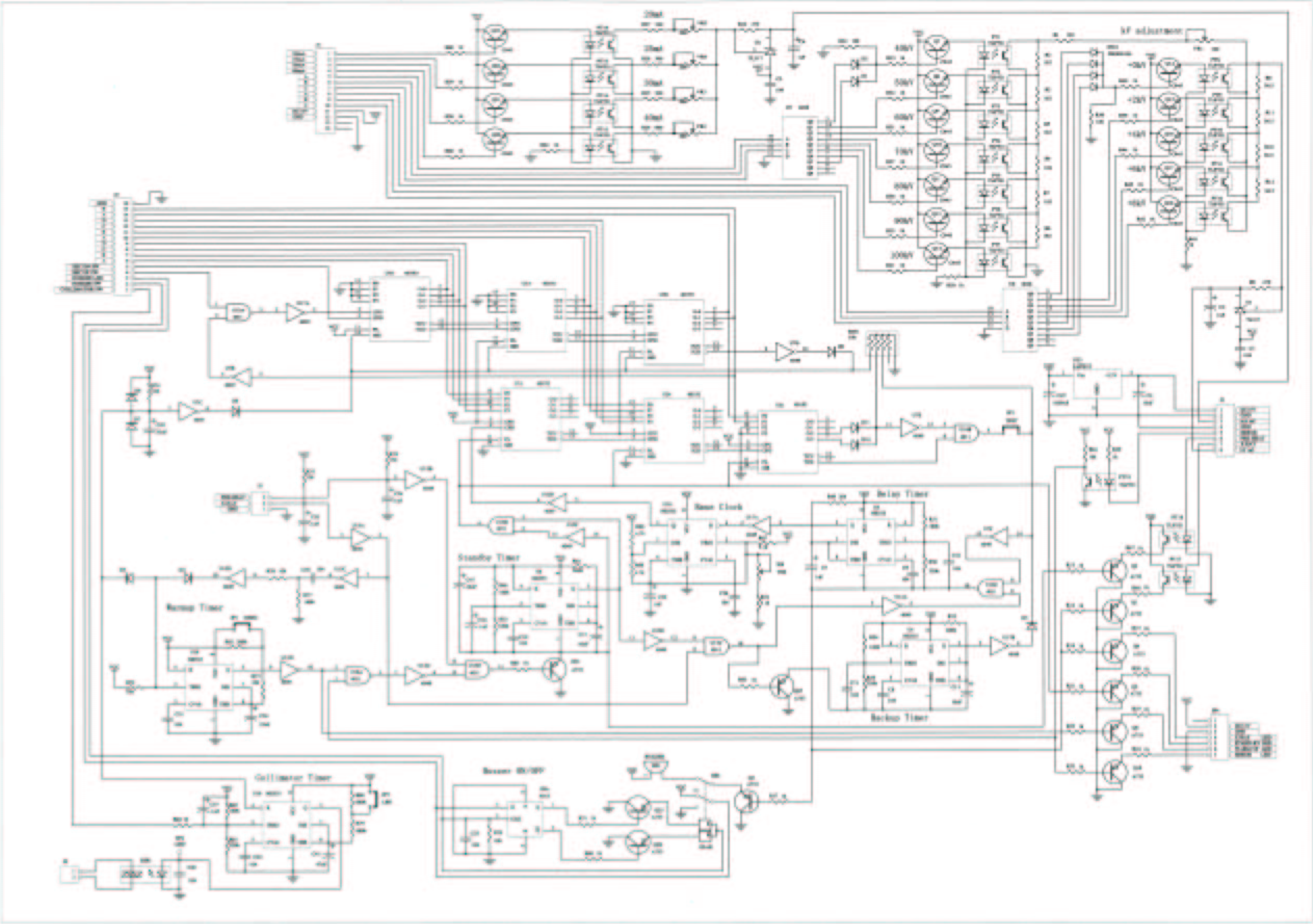
If the symptom is not solved by replacement of insert box, replace inverter, too.

On rare case , IC on M9112 PC Board is damaged by abnormal electrical discharge of x-ray tube.

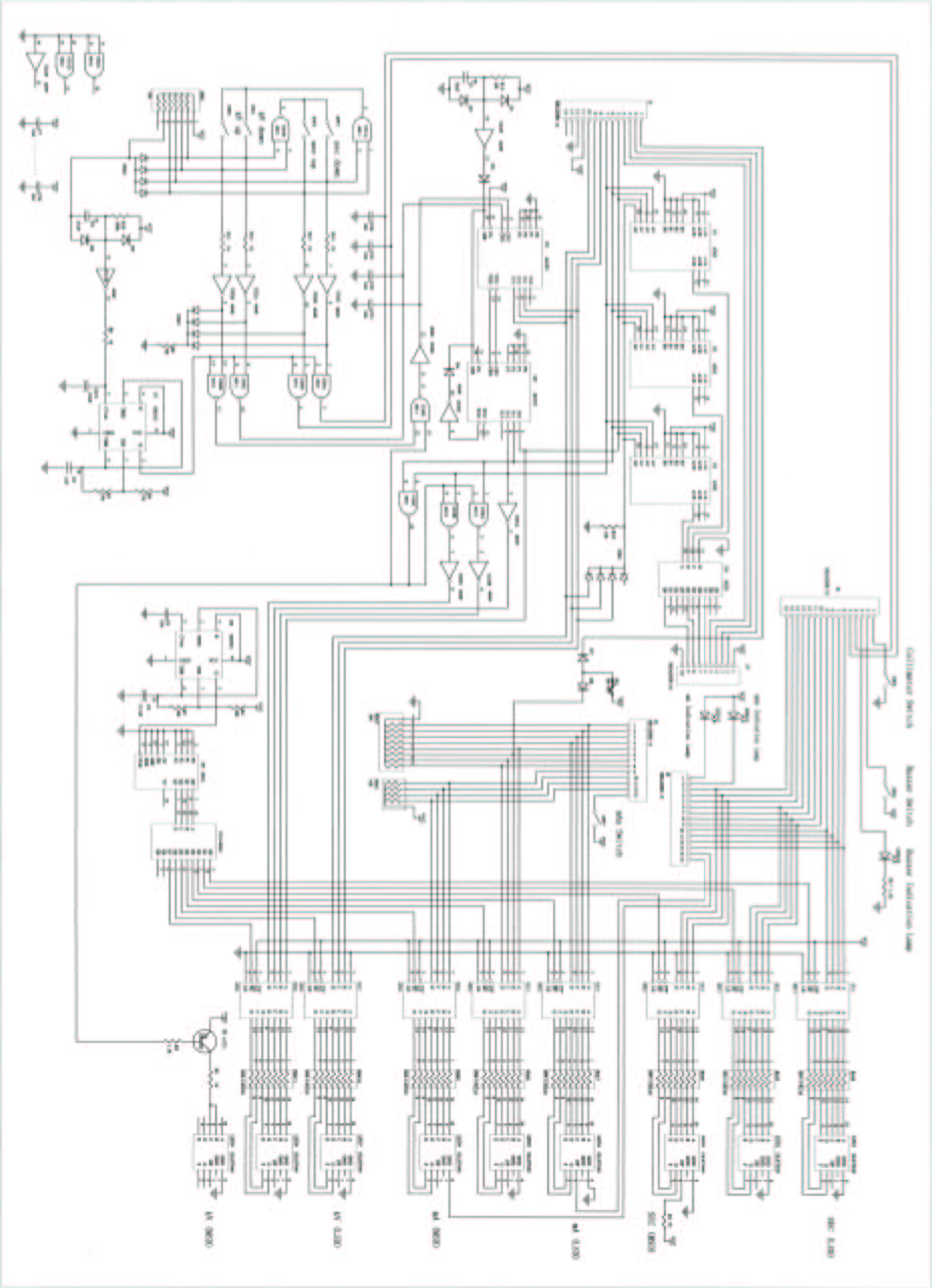
11.0 Wiring Diagram


COLLIMATOR
M3106B
M3108A(HF100H)
M3107B(HF100H)
SVE-24SA
M9112
M9111
M9110

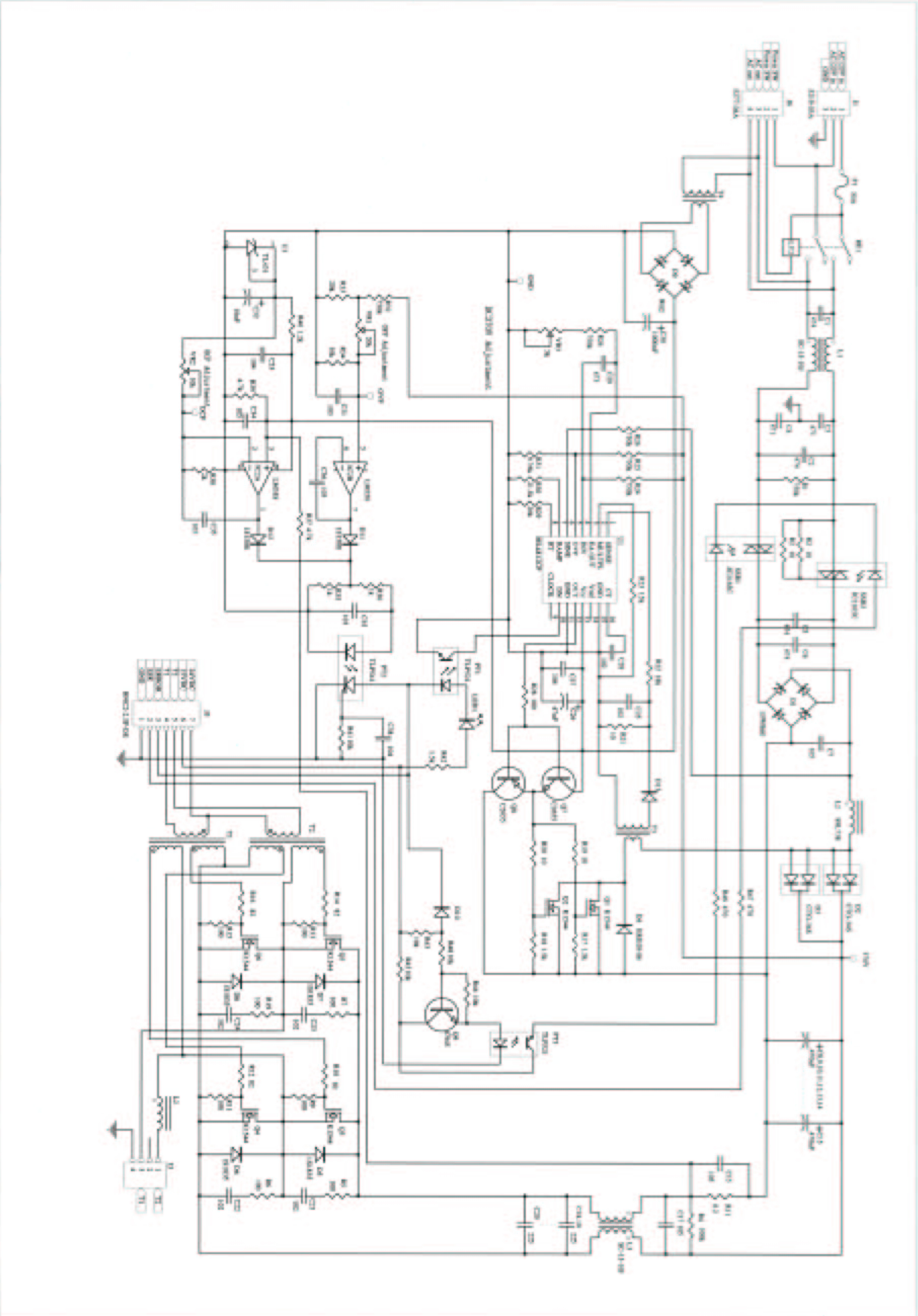
12.0-1 Schematic Diagram


kV adjustment
40kV
50kV
60kV
70kV
80kV
90kV
100kV
20mA
40mA
Base Clock
Delay Timer
Standby Timer
Warmup Timer
Backup Timer
Collimator Timer
Buzzer ON/OFF

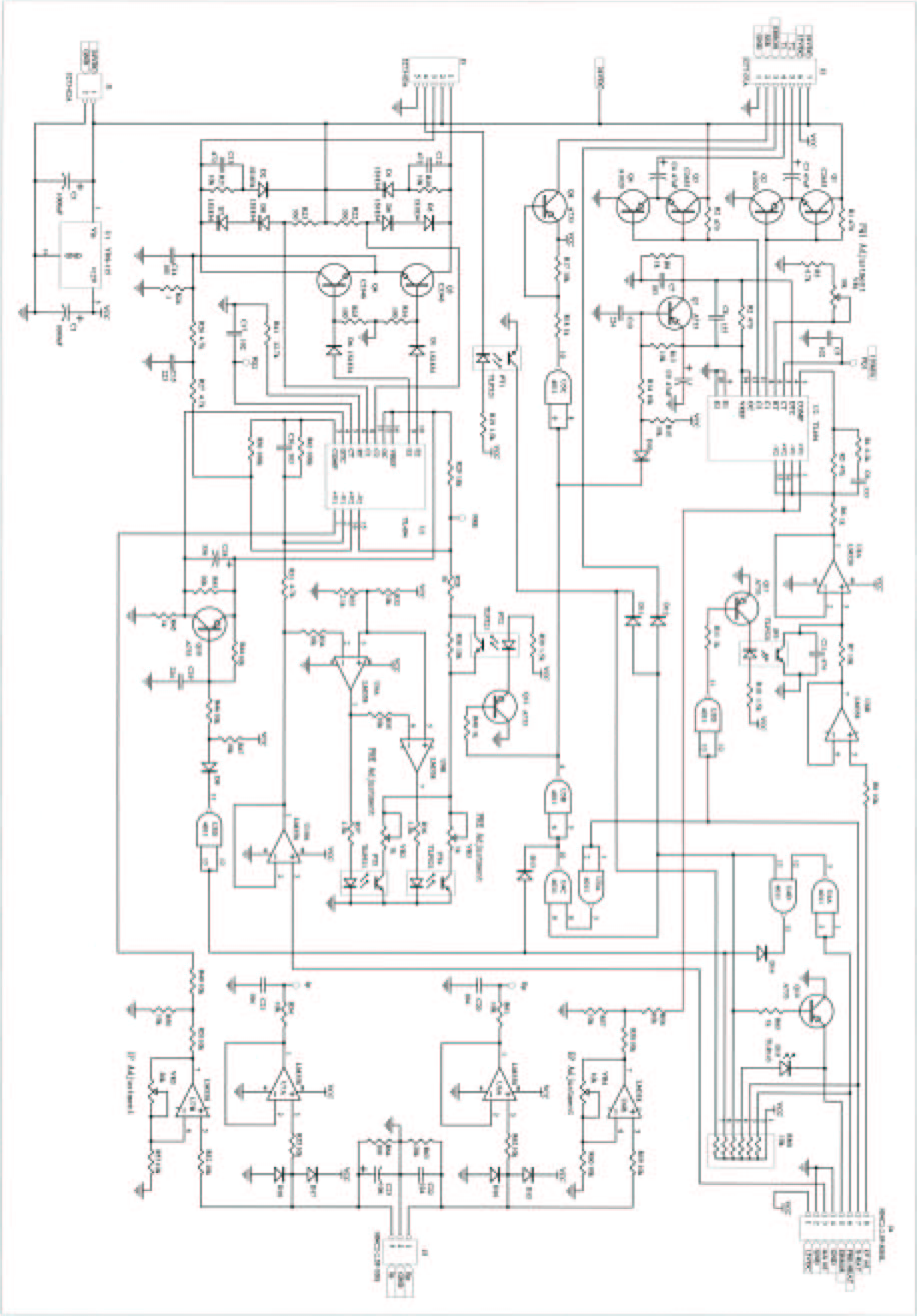
12.0-.2 Schematic Diagram


Collimator Switch
Buzzer Switch
Buzzer Indication Lamp

12.0-3 Schematic Diagram



12.0-4 Schematic Diagram



13.0 HF100H Parts List

Index No.	Parts No.	Designation	Qty
1	11169	COLLIMATOR (D-180HS-G)	1
2	10749	LOWER CASE (YELLOW) (HF100H)	1
3	10586	PLASTIC FOOT (TM-127 No.2)	4
4	10753	TAPE MEASRE (YELLOW)	1
5	10688	FUSE HOLDER	1
6	10742	POWER RECEPTACLE	1
7	10755	EXPOSURE SWITCH CORD RECEPTACLE(65902-004)	1
8	10690	MOUNTING PLATE (WITHOUT DEGREES)	2
9	10081	NYLON WASHER	4
10	10082	METAL SPACER	2
11	10083	SPLIT LOCK WASHER	2
12	10084	HOLDING SCREW	2
13	10584	LEAD CUP WITH 1.0mm AL FILTER	2
14	10818	HOLDING PARTS	2
15	10756	FRONT PANEL (YELLOW)	1
16	11170	MOUNTING RING FOR D-180HS-G	1
17	11171	MOUNTING PLATE	1
18	11172	FIXING PLATE	1
19	11173	SPACER	4
20	10691	PCB M9111(115V)	1
21	10692	SIDE FRAME	2
22	10694	RUBBER PLATE (BOTTOM)	6
23	11174	FIXING MATERIAL	1
24	11066	INSERT (HF100H)	1
25	11142	BRASS RING	1
26	10696	CHASSIS	1
27	10697	SPACER (M3 X 5)	4
28	10718	PCB M9112	1
29	10757	COLLIMATOR TRANSFORMER (474-1002)	1
30	10750	POWER SUPPLY (SVB-24-SA)	1
31	10752	PCB M3108A (HF100H)	1
32	10585	SPACER (M3 X 10)	2
33	10895	PCB M3107BH (HF100H)	1
34	10702	SPACER R-5(6d. X 5)	5
35	10703	PCB M3106 (WITH CORD) (7 segment)	1
36	10748	UPPER CASE COMPLETE LATELING (YELLOW)	1
37	10076	ORNAMENT WASHER FOR ORNAMENT SCREW M3	4
38	10075	ORNAMENT SEREW (EP-M3 X 8)	4
39	10714	LED INDICTING LAMP (ORANGE)	1
40	10713	LED INDICTING LAMP (GREEN)	1
41	10715	LED INDICTING LAMP (RED)	1
42	10760	SHEET KEY PLATE	1
43	10662	POWER SWITCH (MORON-FHA WITH SHIELD)	1
44	10663	POWER SWITCH SHIELD (MORON -FH)	1
45	10708	RUBBER BLOCK	4
46	10709	PLASTIC SHIELD PLATE	1
47	11162	EXPOSURE SWITCH(HS-M1)	1
48	11163	EXPOSURE SWITCH CORD (HS-M1)	1
49	11057	COLLIMATOR FUSE HOLDER & FUSE	1

OPERATOR'S AND INSTALLER'S MANUAL

FOR

"COLLIMAX" X-RAY COLLIMATOR

MODEL D-180HS-G

COLLIMAX CORPORATION
1-11, 2-Chome, Noge
Setagaya-ku, Tokyo, Japan

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** Compatibility Page 2 & 3

** Name of Each Part Page 4

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*** Electrical Supply Requirement Page 5

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* marked : Common to Operators and Installers.

** marked : For Operators Only.

*** marked : For Installers Only.

FOREWORD

This manual is prepared to guide the use of "Collimax" Model D-180HS-G X-Ray Collimator. This manual provides explanations of the function, operation and maintenance procedures etc.

One who installs and or uses this collimator must read this manual with care to understand this product prior to installation and operation.

WARNING

"Collimax" Model D-180HS-G X-Ray Collimator is designed and constructed within the specifications imposed by DHEW and within practical limitations to provide protection against all unwanted x-radiation emissions. One who installs and or uses this collimator must be well acquainted with instructions in this manual pertaining to the proper use.

SECTION I. PRODUCT DESCRIPTIONS

General Description

This X-Ray Collimator is designed for such applications as shown in the " Specifications" of this manual and must be used with the x-ray tube to restrict and define the area covered by the x-ray beam and also to reduce stray radiation. The beam that is collimated by the 2 control knobs should cover the smallest area of the patient neccessary to produce the required radiograph. The collimator that allows a stepless adjustment of a field size utilizes a light localizer to project a visible beam with coverage equivalent to the coverage of the x-ray beam.

Features and Performances

1. Provided with a bush button timer to automaticallly switch off the lamp of light localizer in 30 seconds.

2. Equipped with special Ring Device by which the center of collimator is adjustable by ±2 mm to align the center of visible beam with the one of x-ray beam, and yet the collimator can be self rotated.

3. The lamp of light localizer is easily replaceable with minimized error of the same lamp position and the lamp filament position can be easily adjusted.

4. Maximum shutter opening of collimator is less than 35 cm x 35 cm at SID 65 cm.

5. Minimum x-ray field size at SID 100 cm is less than 5 cm x 5 cm.

6. The average illuminance of light field at SID 100 cm is 180 lux or more.

7. The contrast ratio on the light field edges is 3.5 : 1 or more, which allows an easy identification of light field and its size.

8. Provided with calibration scales indicating the light field sizes at each SID which accuracy variance is within 2 % of SID.

9. The leakage radiation at SID 100 cm is within 50 mR/h.

10. The insulation resistance between source circuit and a grounding metal is 2 M ohm or more.

11. The electric resistance between a grounding terminal or a grounding metal and outer case is not more than 0.1 ohm.

12. The collimator can endure, for a minimum of one minute, AC 1500V between AC line terminal and a grounding metal.

Specifications

1. Applications:	For general purpose mobile x-ray units, and special purpose radiographic unit designed for use with a fixed image receptor size at a fixed SID.
2. Maximum KVP:	125kvp.
3. Outer Dimensions:	182mm × 197mm × 140mm.
4. Net Weight:	(approx.) 5.9kg.
5. Shutters Drive:	By 2 manual control knobs.
6. Projiction Lamp:	Philips Type 7158 Halogen Lampm, 24V/150W rated, or an equivalent Halogen lamp of the same rating.
7. Power Supply to Lamp:	AC 19V (under load), measured at lamp socket, or more.
8. Lamp Switch:	Push Button Type 30 seconds Electronic Timer.
9. Minimum Line Current:	5.8A at AC 19V under load, or more.
10. Maximum Field Size:	35cm × 35cm at SID 65cm.
11. Minimum Field Size:	Less than 5cm × 5cm at SID 100cm.
12. Min. Alminum Equivalence:	0.4mm Al at 100kvp.
13. Installation Method:	By installation of adaptor flange on tube housing with 4 bolts, and diagonal length of the 4 installation bolts is 92mm. Other installation methods are optionally available.
14. Tube Focal Distance:	60mm, as the standard tube focal distance, from tube focus to the bottom surface of adaptor flange, but adjustable between 60mm - 52mm by use of spacers that are supplied with each collimator.

Compatibility

This collimator is compatible and can be adopted for use with any x-ray tube (with tube housing) that meets all of the following factors.

1. Focal Distance of X-Ray Tube:
   Adjustable between 60mm (standard) - 52mm from tube focus to the bottom of adaptor flange of this'collimator by use of the spacers. For 60mm tube facal distance, the spacers are not used. For tube focal ditance of less than 60mm, use the spacer(s) to obtain each correct tube focal distance in view of compliance with Performance Standard (e.g., 52mm: 2pcs. × 2mm thick spacers).

2. Installation Method:

By installation of adaptor flange on tube housing with 4 bolts, and diagonal length of the 4 installation bolts is 92 mm.
Other installation methods are optionally available but they must be consulted in advance with the manufacturer of this collimator.

3. Leakage Radiation:

Maximum leakage radiation from tube housing assembly must be within 50 mR/h at SID 100 cm.

4. Inherent Filtration:

Inherent Filtration of this collimator is 0.4 mm Al at 100 kVp.

5. Half-Value Layer:

Half-value layer of useful beam at a x-ray tube voltage must not be less than the values shown in Table 1 of (m) Beam Quality of Section 1020.30 under Performance Standard.

6. Applications:

For general purpose mobile x-ray systems, and special purpose radiographic systems designed for use with a fixed image receptor size at a fixed SID. Maximum tube voltage of those x-ray systems must be 125 kVp or less, in the output.

7. Power Supply to Collimator Lamp:

Loading voltage and maximum line current to collimator lamp must be AC 19 V or more and 5.8 A or more respectively, being measured at the lamp socket under load.

Note: Collimator lamp to be used must be Philips Type 7158 Halogen Lamp, rated 24 V/150 W or an equivalent Halogen Lamp of the same rating that meets the international standard (of same filament size and shape).

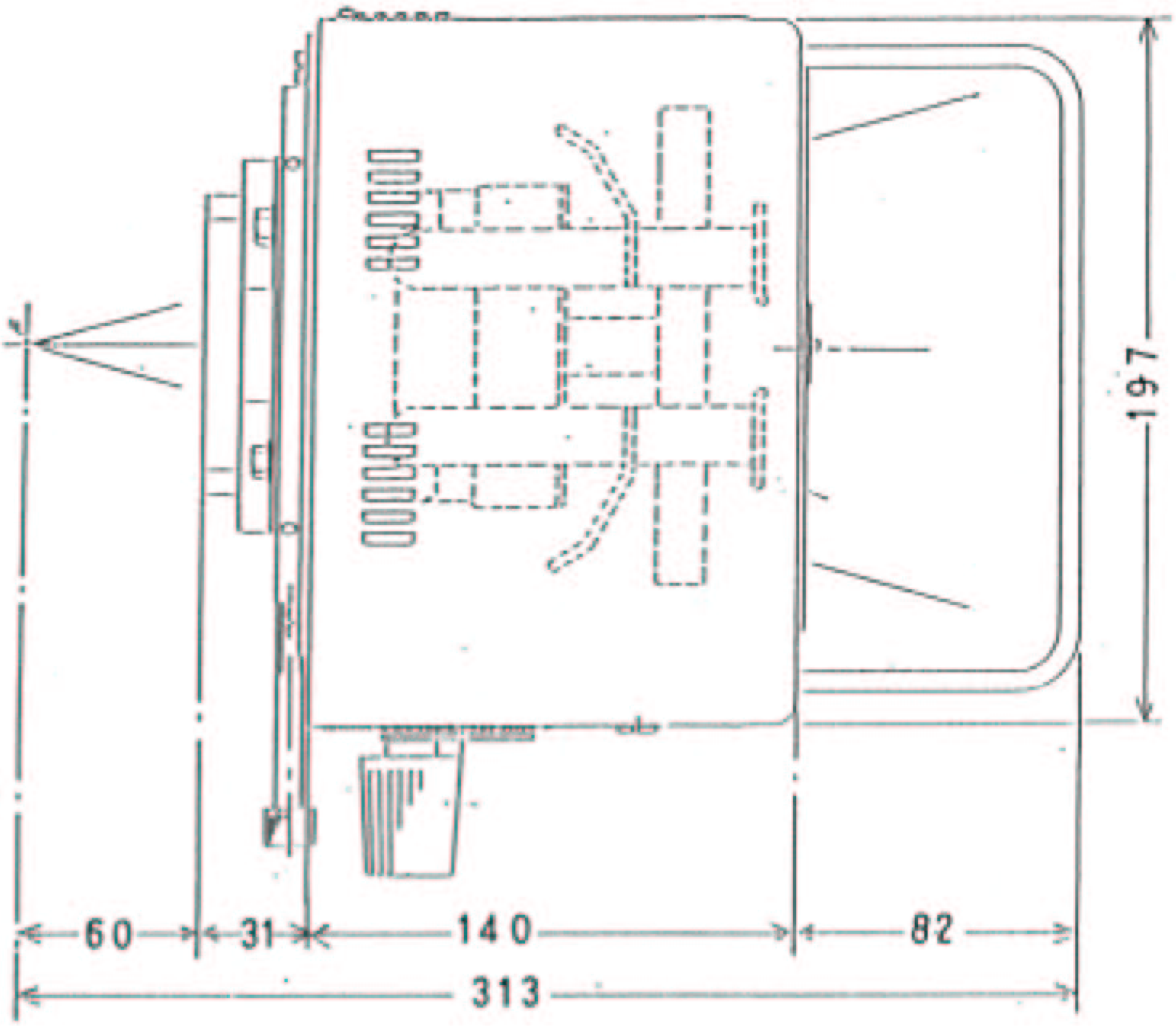
8. Others:

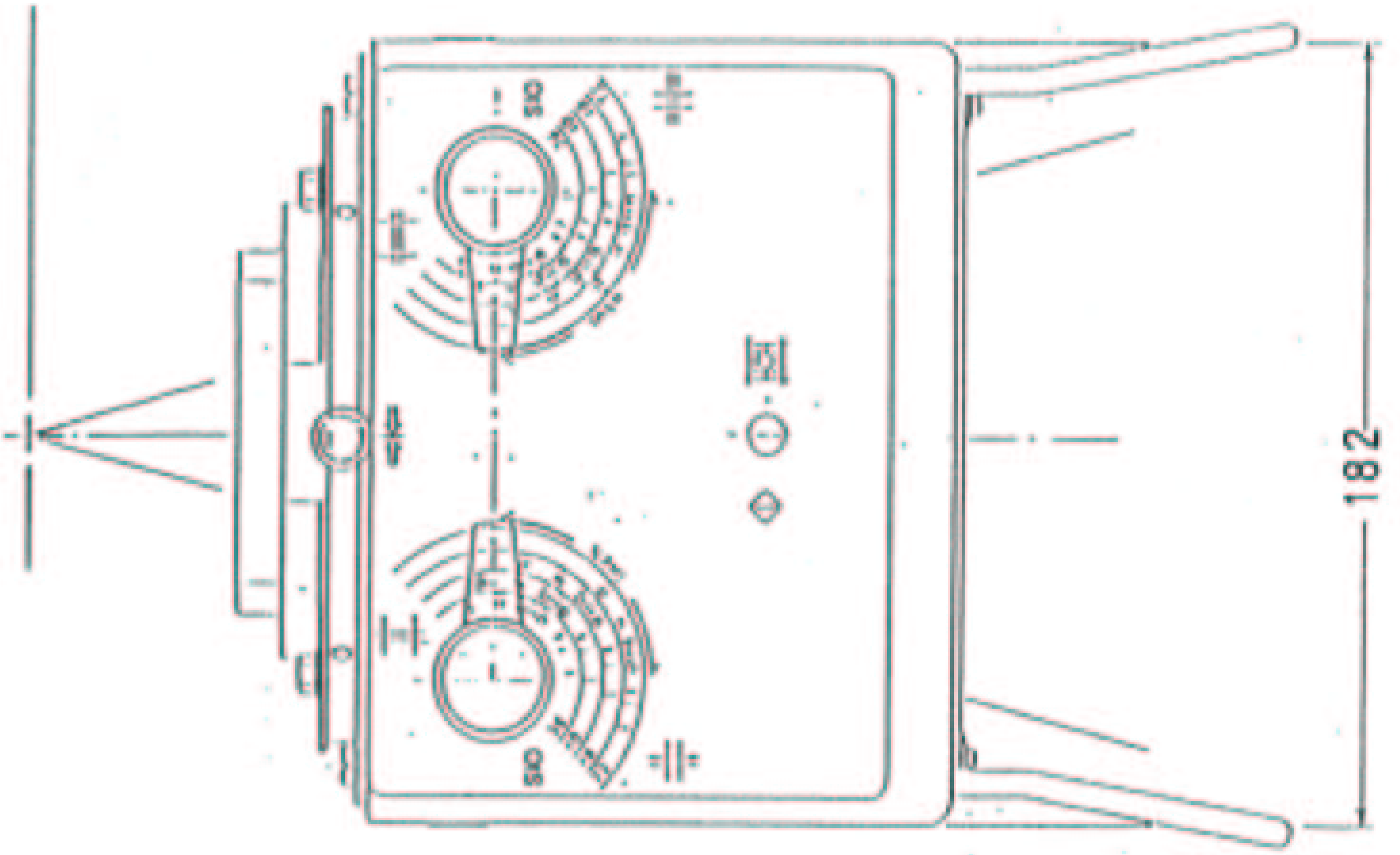
When collimator was combined with x-ray tube, D.S.A.(Diagnostic Source Assebly) must have illuminance of 180 lux or more at SID 100 cm, Contrast Ratio of 3.5:1 or more at SID 100 cm, and Misalignment (of light field with x-ray field) of not more than 2 % of SID.

Name of Each Part

See the drawing of next page.

Outer Appearance and Dimensions and Name of Each Part


60
31
140
82
313
197



SECTION II. INSTALLATION AND OPERATION

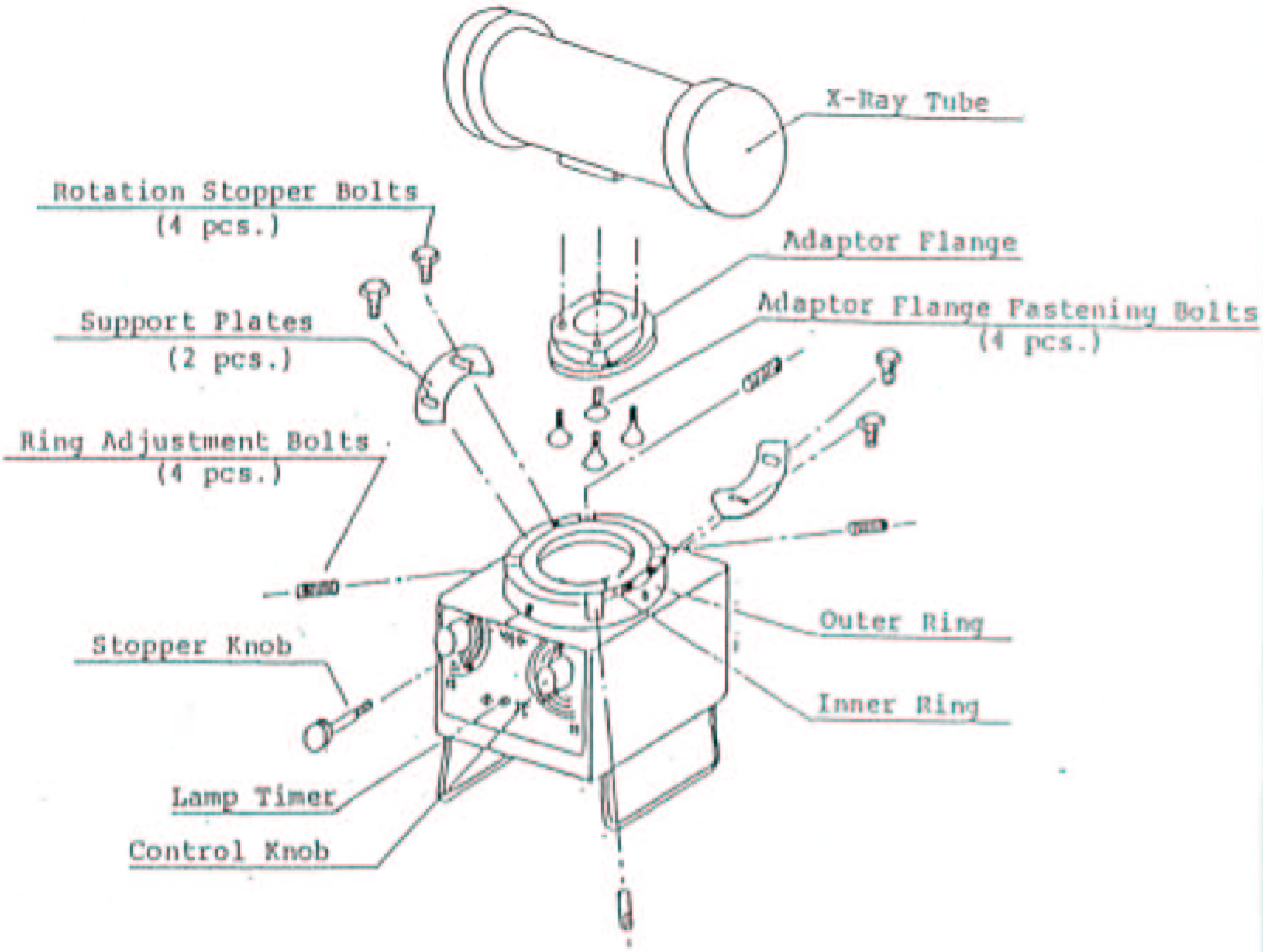
Responsibility of Installer

It is the responsibility of the installer to correctly install this collimator as instructed in this manual. The installer must certify that the x-ray equipment on which tube housing assembly the colllimator was installed is in compliance with DHEW Regulations.

Electrical Supply Requirement

It is imperative that a sufficient power is supplied to the collimator lamp to obtain the specified voltage under on-load condition being measured at the lamp socket. to keep this collimator in compliance with DHEW Regulations.

Installation Method (see drawing as shown below)


X-Ray Tube
Rotation Stopper Bolts
(4 pcs.)
Adaptor Flange
Adaptor Flange Fastening Bolts
(4 pcs.)
Support Plates
(2 pcs.)
Ring Adjustment Bolts
(4 pcs.)
Outer Ring
Inner Ring
Stopper Knob
Lamp Timer
Control Knob

1. Install the adaptor flange on tube housing assembly with 4 installation bolts.

2. Hold the collimator and place its Inner Ring over the adaptor flange, then fix the 2 Support Plates, temporarily, with the 4 Rotation Stopper Bolts.

3. Fasten Stopper Knob not to allow collimator to rotate.

4. Connect the power supply cord of lamp and push Lamp Timer to confirm that the lamp is illuminated.

5. Adjust collimator position with 4 Ring Adjustment Bolts so that the center of adaptor flange will be aligned with the center of the inner ring, then fasten firm the 4 Rotation Stopper Bolts.

6. Push Lamp Timer and make sure that light field can be collimated to a required size by operation of 2 manual control knobs.

Operation

1. Push Lamp Timer and confirm that light field is illuminated.

2. Adjust collimator position so that the centering cross mark of collimator is aligned with the center of an image receptor.

3. Collimate light field to the image receptor size operating the 2 manual control knobs.

Cares to be Taken on Operation

1. Do not fail to use within the specified maximum tube voltage.

2. Do not use installing on those x-ray tubes which focal distances are different from the ones specified.

3. If lamp replacement became neccessary, do after the inside temperature decreased sufficiently.

4. Never fail to use the same type of lamp as specified.

5. Do not touch on the projection lamp, plastic mirror and front acrylic plate except when it became neccessary to do so.

6. In case lamp was illuminated successively 5 times or so, keep it off for about 2 minutes till next operation for cooling purpose.

SECTION III. INSTRUCTIONS FOR MAIN ADJUSTMENT DEVICES

Lamp Replacement and Adjustment Method of Lamp Filament Position

1. For replacement of lamp, first remove the lamp cover, then remove the screen plate of lamp house, but never move the front acrylic plate.

2. Make sure first that the lamp surface temperature sufficiently decreased, and pull lamp out of the socket.

3. Wrap over the replacement lamp surface with a soft cloth or the like so as not to allow a finger to touch on the surface, and insert the lamp into the lamp socket so that the lamp pins will reach to the utmost depth of the lamp socket, then install the screen plate of lamp house.

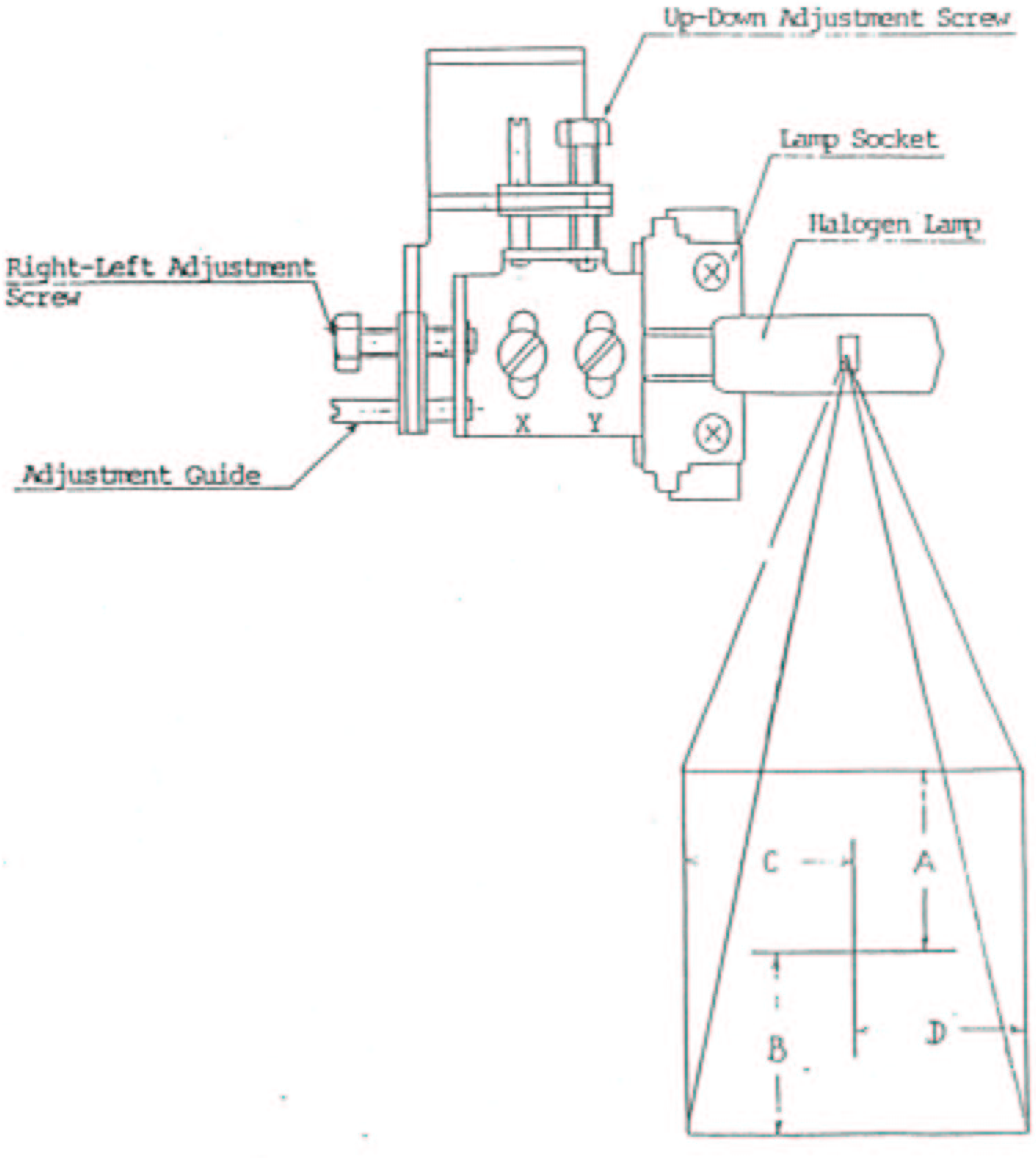
4. After the replacement work, illuminate the lamp by pushing lamp timer, and measure if the centering cross mark is in the center of light field.

5. If the centering cross mark should be drifted from the center, adjust the lamp filament position as follows (see the drawing of next page).

1) Measure A size and B size:
In case A size was larger, loosen the Locking Screws(X & Y) and turn the Up-Down Adjustment Screw to left. In case B size was larger, turn the Adjustment Screw to right.

2) Measure C size and D size:
In case C size was larger, turn Right-Left Adjustment Screw to left. In case D size was larger, turn this Adjustment Screw to right.

3) At the position where A & B and C & D of light field became equal to each other lock lamp position by fastening firm the Locking Screws (X & Y).


Up-Down Adjustment Screw
Lamp Socket
Halogen Lamp
Right-Left Adjustment Screw
Adjustment Guide
X
Y
A
C
B
D

Alignment Check and Adjustment Method

1. This collimator is designed and factory adjusted to comply with Performance Requirement when it was correctly installed as specified in this manual, so far as the x-ray tube focus (target) position is correctly aligned with the center of the x-ray tube window.
   However, the misalignmeent of light field with x-ray field can be checked and adjusted, as follows, if there might be a possibility that the misalignment might exceed 2 % of SID due to the Off-Center of tube focus position and or if check of misalignment was required.

2. Prepare a fluorescent paper on which the center and a field size are marked (e.g., a center cross mark and 125 mm x 125 mm, or 250 mm x 250 mm, or 350 mm x 350 mm).

3. Place the fluorescent paper on a flat surface so that it becomes perpendicular to the center line of light beam. Illuminate collimator lamp and align the center of fluorescent paper with the center cross mark of light field, at SID 100 cm, then collimate to the size marked on the fluorescent paper.

4. Make a longest possible x-ray exposure (if fluoroscopic condition is not available) and observe if the x-ray field is aligned with light field. If there'd be a noticeable misalignment (entire field is usually drifted to one direction due to the off-center of tube focus position), adjust the entire collimator positionn as below.

   1) Keep collimator mounted on x-ray tube, and a little loosen 4 pcs. of Rotation Stopper Bolts (see drawing in "Installation Method"), then loosen 4 pcs. of Ring Adjustment Bolts.

   2) Make x-ray exposure aagain and confirm that x-ray field is aligned with the field size marked on the fluorescent paper (if neccessary, collimate x-ray field to the marked fielld size).
      Illuminate collimator lamp and align the light field size to the x-ray field size by adjusting the colllimator position.
      At the position where it was aligned, fasten the Ring Adjustment Bolts and also fix the Rotation Stopper Bolts.

   3) If there'd be still a noticeable misalignment after above work and if there'd be a need to further adjust, the alignment can be adjusted by moving the lamp position as described in "Lamp Replacement and Adjustment Method of Lamp Filament Position".

   4) In case of alignment check with a radiographed film, prepare a film cassette a little larger than the field size, illuminate lamp timer, measure the light field edges and mark them on the film cassette with a fuse wire or the like, then make a radiography and measure the misalignment on the developed film.
      The said mark with a fuse wire etc. will be placed so that it appears on the developed film even when x-ray field was smaller than light field.
      The radiography will be made under minimum required condition.
      If the misalignment measured on the radiographed film should exceed 2 % of SID as required by Performance Standard, further adjustment of alignment can be made in the same manner as above described.

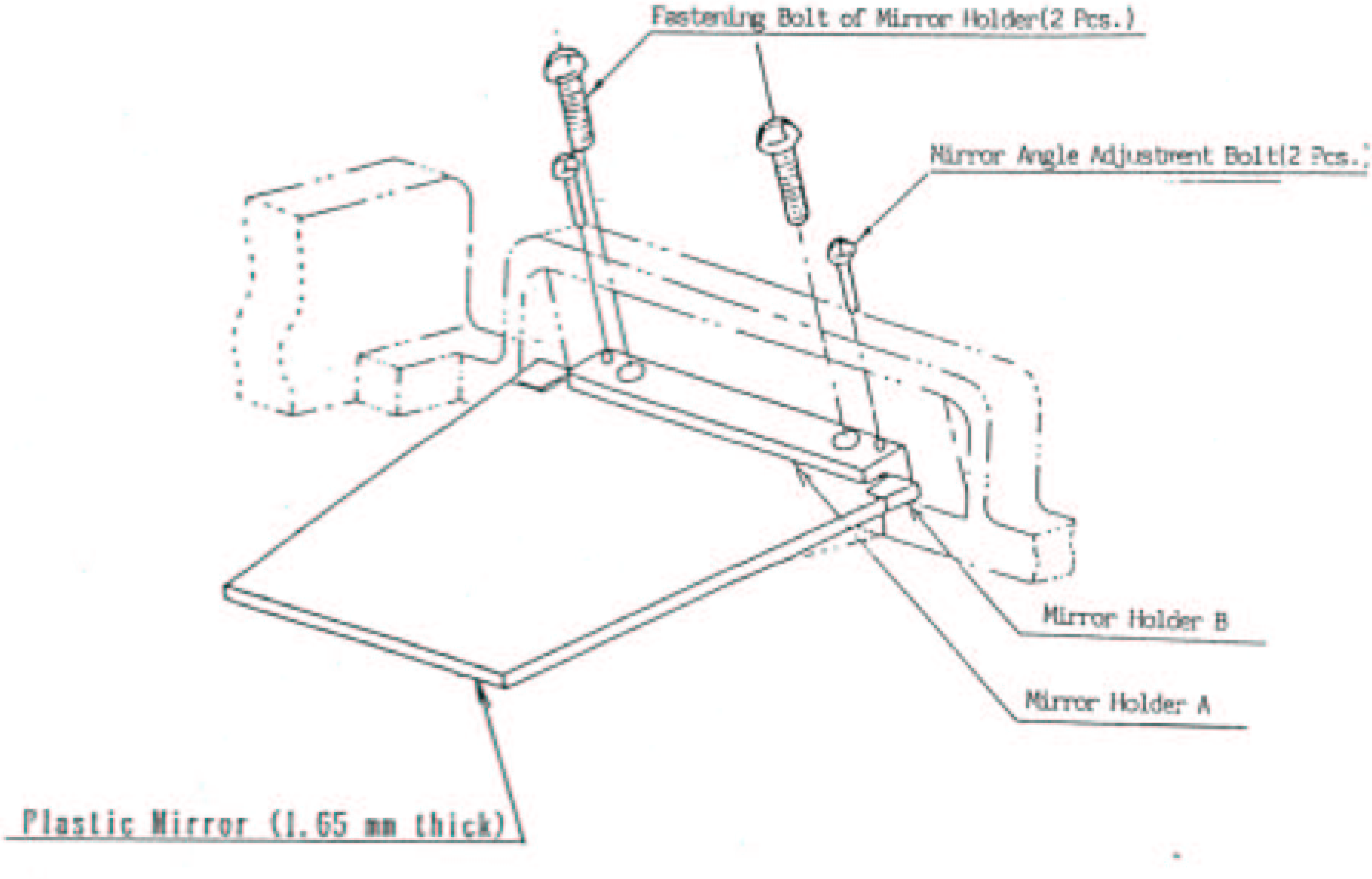
Plastic Mirror Replacement Method

1. For replacement of plastic mirror, first remove the front acrylic plate, and open collimator shutters to the maximumpositions in both of longitude and latitude.

2. Remove the installation screws of mirror holder (2 pcs.) and mirror holder A. Then, remove the plastic mirror with mirror holder B that is binded to the mirror.

3. Install the replacement plastic mirror fastened with mirror holder A, then temporarily fix the front acrylic plate.

4. Place a thin paper in front of the acrylic plate, then illuminate the lamp and gradually collimate the light field in both of longitude and latitude. At the position where the centering cross mark was aligned with the center of light field, lock the front acrylic plate with its 2 fastening screws.


Fastening Bolt of Mirror Holder(2 Pcs.)
Mirror Angle Adjustment Bolt(2 Pcs.)
Mirror Holder B
Mirror Holder A
Plastic Mirror (1.65 mm thick)

SECTION IV. MAINTENANCE

1. Make a cleaning, every 3 months, of the front acrylic plate, collimator case and lamp surface. If a finger touched on the lamp surface, wipe out the finger print.

2. The plastic mirror will be replaced at any time if it was broken.

3. Make sure, before every use, that the lammp is illuminated when pushed the lamp timer.

4. Periodically check and make certain that warning label has not been defaced or worn so as to be illegible.

Compliance Maintenance Schedule

1. Conduct Illuminance Test, once a year and whenever lamp was replaced, to make certain that the average illuminance of light field at SID 100 cm is 180 lux or more.

   If the measured illuminance was less than 180 lux, check the loading voltage and line current to the lamp, and when necessary, replace the lamp to a new one, then again make sure that the illuminance is not less than 180 lux.

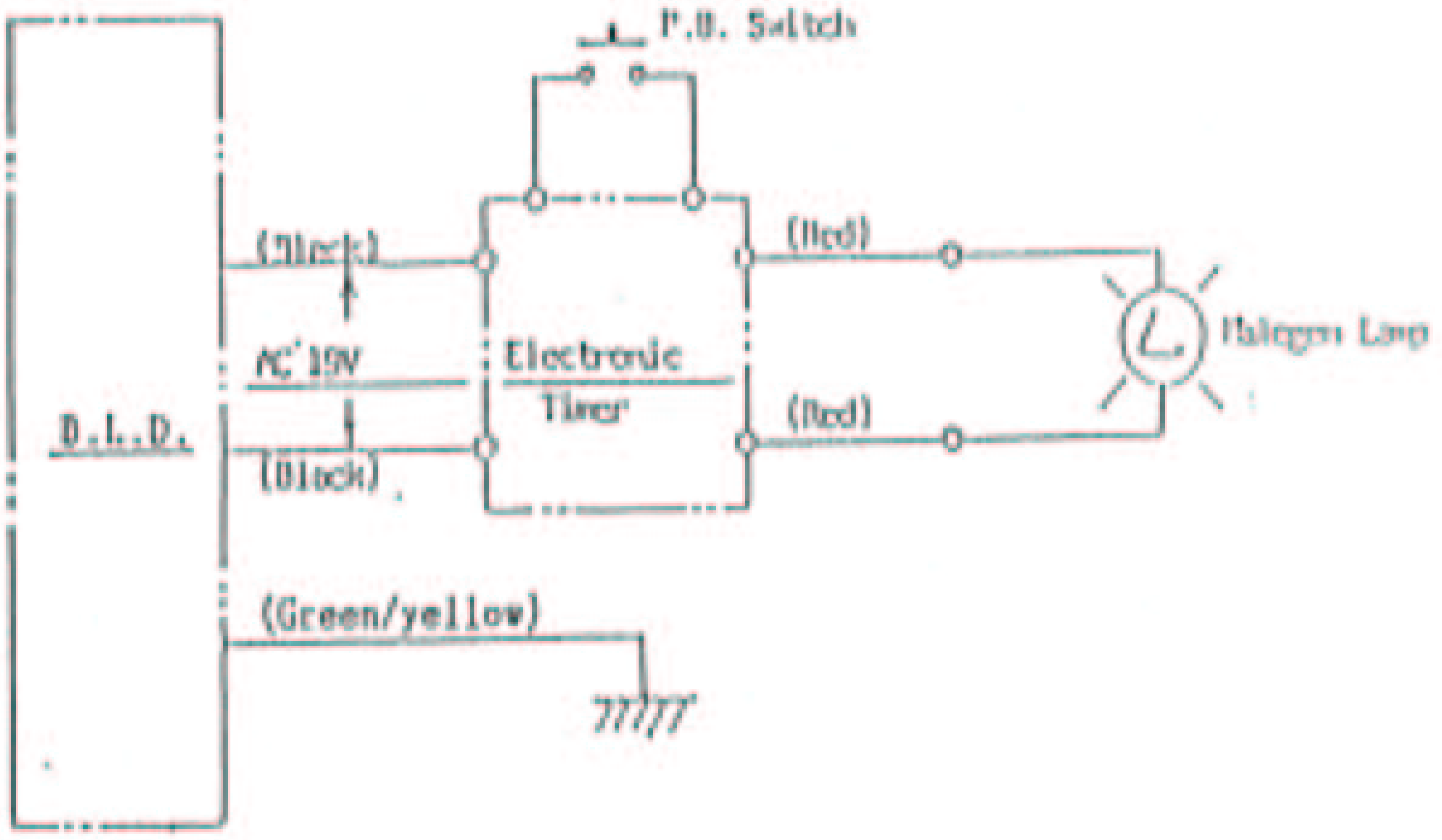
   Note: The replacement lamp must be Philips Type 7158 Halogen Lamp, rated 24 V/ 150 W or an equivalent Halogen Lamp of the same rating that meets the international standard (of same filament size and shape).

2. Make sure, whenever lamp was replaced, that the centering cross mark of collimeter complies with the center of light field. If it is drifted from the center of light field, adjust the lamp filament position till both the center comply with each other.
   For adjustment method, see "Lamp Replacement and Adjustment Method of Lamp Filament Position" in Section III of this manual.

3. Check once a year and whenever lamp was replaced, and make certain that the contrast ratio of light field is 3.5:1 or more at SID 100 cm.

4. Check once a year and whenever lamp was replaced, and make certain the misalignment of light field with x-ray field is within 2 % of SID.
   If the misalignment should be more than 2 % of SID, adjust it to within 2 % of SID. For the adjustment method, see "Alignment Check and Adjustment Method" in this manual.

CIRCUIT DIAGRAM



15.0-1 Pre-adjustment with HF Tester

The HF tester is a tool to inspect and adjust a control panel.

The upper control panel is removed from the body after four screws on the side of the body are removed.

The control panel is connected with the body with three cables of the power supply cable, interface cable, earth wire, and remove these three cables.

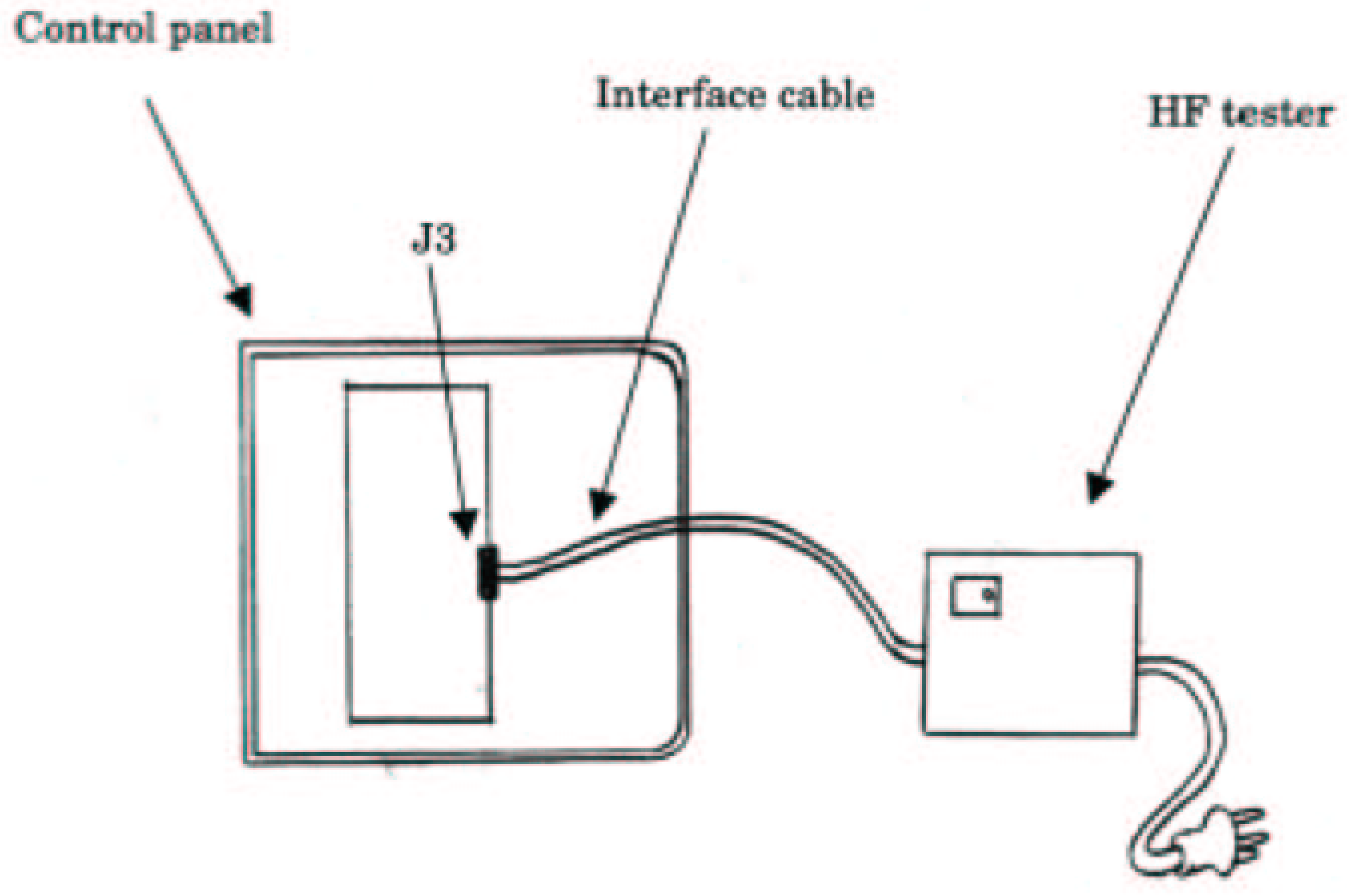
Connect the interface cable of the HF tester to J3 of the M3108 circuit board of the control panel.

Connect a HF tester with the power supply, and turn on a power switch.

kV can be measured with kV+ and the GND terminal.

mA can be measured with mA+ and the GND terminal.

Exposure time can be measured with TIM+ and the GND terminal.



15.0-2 Pre-adjustment without HF Tester

• • Each PC Board delivered from the factory has already been adjusted.

1. M3108A adjustment (Refer to page 8)

kV adjustment : **kV is decreased by turning VR1 clockwise.**

1. Set the kV selector to 100kV.
2. Check the DC voltage between the connector J3-8pin (+) and J3-2pin (-) on the M3108A PC board. (Do not remove any cable.)
3. Adjust the DC voltage to be 5V by turning VR1.

mA adjustment : **mA is decreased by turning VR5 clockwise.**

1. Confirm the mA indicator to be 20mA.
2. Check the DC voltage between the connector J3-3pin (+) and J3-2pin (-) on the M3108A PC board. (Do not remove any cable.)
3. Adjust the DC voltage to be 2V by turning VR5.

HF100H TECHNIQUE CHART*

X-ray Unit: **MinXray *HF100H***
Focal-Film Distance: 40 inches (100 cm)
Tube Current: 20 mA

VIEW	kVDC	~250 SPEED CR or DR IMAGING SYSTEM TIME (sec.)	400 SPEED SCREEN/FILM IMAGING SYSTEM TIME (sec.)	GRID
AP Skull	90	0.40	0.18	6:1, 85L
Lat Skull	80	0.30	0.14	6:1, 85L
AP Chest	80	0.30	0.14	None
Lat Chest	86	0.50	0.20	6:1, 85L
Shoulder	70	0.24	0.10	None
Elbow	60	0.16	0.08	None
AP Hand	56	0.14	0.08 (48")	None
Lat Hand	56	0.14	0.08	None
C-Spine	80	0.44	0.20	6:1, 85L
AP T-Spine	90	0.50	0.22	6:1, 85L
Lat T-Spine	96	0.80	0.34	6:1, 85L
AP L-Spine	96	0.80	0.34	6:1, 85L
Lat L-Spine	96	1.80	0.75	6:1, 85L
AP Abdomen	84	1.00	0.40	6:1, 85L
AP Pelvis	84	0.90	0.38	6:1, 85L
Lat Hip	90	0.70	0.30	6:1, 85L
Femur	80	0.60	0.25	6:1, 85L
Knee	70	0.30	0.13	None
Ankle	60	0.24	0.10	None
AP Foot	60	0.20	0.08	None
Lat Foot	64	0.24	0.10	None

Final results depend on many factors. Therefore, if images are too dark (overexposed), decrease time; if films are too light (underexposed), increase time.

**These are recommended starting techniques for an average size patient. For smaller patients, decrease times slightly. For obese patients, increase times considerably. Adjust times accordingly if using an imaging system with a relative speed different from those listed above, using a different focal-film distance, or varying the kVDC settings.*

MINXRAY® INC.

3611 Commercial Avenue
Northbrook, Illinois 60062-1822, USA
1-847-564-0323
Toll Free 1-800-221-2245
FAX: 1-847-564-9040
E-mail: info@minxray.com
Web: www.minxray.com